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APPLIED MECHANICS REVIEWS

VOL. 7, NO. 1 MARTIN GOLAND *Editor* JANUARY 1954

A NEW ERA IN STRUCTURAL ANALYSIS

E. E. SECHLER

PROFESSOR OF AERONAUTICS, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

EARLY STRUCTURAL PROBLEMS

EVER since man first wove vines together to make a crude rope or used a fallen tree as a means of crossing a stream, he has been dependent upon some form of strength analysis for his safety and his welfare. The earliest forms of strength analysis were by obvious trial-and-error methods. If a member held the load placed upon it, it was strong enough and, if it broke, it was too weak and was replaced by a larger member. It is difficult to realize that early civilizations built such structures as the Roman Aqueduct, the Greek Parthenon, and the temples of ancient China and Egypt long before the existence of any knowledge concerning strength of materials or the relationships between load, strength, and deflections.

It was not until the early part of the 17th century that any curiosity was shown concerning the underlying reasons for deflection and rupture under load. Galileo attempted to find the laws governing the deflection and failure of a cantilever beam, and his interest in this problem ultimately led to the discovery of Hooke's law (1660) and the formulation of the general equations of elasticity by Navier (1821). The investigation by Bernoulli and Euler of columns and other forms of unstable structures also occurred in this period of discovery.

THE EFFECT OF THE INDUSTRIAL REVOLUTION

The 19th and early part of the 20th centuries saw great development of machine tools, methods of transportation, and other artifacts of the machine and industrial age. Bridges were built; automobiles and other forms of transportation were designed and became mass produced; and textile, printing, and other large industries required tools and machinery for their operation. In all of these, the tool and machine designer was faced with the problem of designing load-carrying elements so that they would safely support the loads placed upon them and would not suffer excessive displacements under these loads. His major structural materials were wood, iron, steel, brass, and later, the aluminum and magnesium alloys. Except for the latter, his constructional materials were generally cheap and, since weight was seldom of any importance, an increase in the amount of material seldom resulted in a penalty to the finished products. An important factor in this regard was the fact that, at first, speed was of secondary importance. Transportation, only one step removed from horse-drawn vehicles, was slow and machine production did not need to be fast to greatly increase output over hand-produced items. Thus, acceleration and inertia forces were insignificant and the slow velocities of vehicles and machines made weight reduction unimportant.

As a consequence of cheap materials and no importance being given to weight, relatively crude analysis methods for structural strength and deflection were satisfactory. The simple beam, column, and axial-load equations of strength of materials were used to obtain the working stresses, and the allowable stresses were reduced by suitable "factors of safety" to cover up any lack of accuracy in the analysis. These so-called "factors of safety" were really "factors of ignorance" since they were designed to account for the stress concentrations, the stresses due to acceleration and impact, and all of the many other items not covered by the simplified analyses of the time. Complex stress patterns, such as those in gear teeth, were reduced to simple terms by assumptions both as to the load and its method of support by the structure, and then correction terms were applied to the final result. These correction terms were usually obtained by a combination of experimentation, experience on similar designs, and semi-empirical analysis.

INFLUENCE OF WAR PERIODS

World War I suddenly changed the entire picture in so far as structural analysis was concerned, and events since that time have shown that we have entered an era of vital importance to the stress analyst and designer. The advent of the airplane introduced two new concepts into industry and transportation, namely, the need for light weight and the advantages of speed. The war periods also emphasized quantity production on scales heretofore unknown which made it necessary to design machines to run faster and thus be subject to acceleration, impact, and fatigue loads which were so large that they could not be ignored. Recently an additional factor has entered the problem in that material costs have risen to an extent that, in many cases, it is no longer cheaper to add material than it is to spend additional time on analysis in order to reduce the size of a machine component.

One other item that is becoming of greater and greater importance is the effect of high temperatures on the stress and deflection of machine parts as well as its effect on the allowable stresses of any given material. Plastic flow and high temperature creep must be considered by the stress analyst as well as the effect of temperature terms on the basic equations of elasticity. High temperatures in conjunction with high stresses are becoming

more important in such industries as petroleum refining and power generation and are now entering the airframe industry due to the aerodynamic heating caused by high-speed flight.

Whereas in the past it was sufficient to design a machine so that it would satisfactorily and safely perform the duties for which it was intended, the same machine now must perform the same work in a fraction of the previous time and also frequently must be as light as possible. For this reason, crude analysis methods are no longer acceptable and the designer must know exactly what stresses and deflections exist in all parts of the machine so that he can make an economical choice of the material to be used for each component. These stresses must include not only those due to static loading but also impact and inertia stresses due to accelerations as well as any thermal stresses which may be present. The rapid motion of machines also emphasizes the importance of fatigue failures since the number of operational cycles in a given time is constantly being increased.

ECONOMIC CONTRIBUTIONS OF THE STRESS ANALYST

A few examples may serve to show that the contribution of the stress analyst to a particular design may be very far reaching in its implications.

(a) If, by proper analysis, suitable choice of material, and a reduction in unnecessary factors of safety through accurate analysis procedures, the wall thickness of a 30-inch diameter pipe could be reduced an average of one-sixteenth of an inch, it would save over 50,000 tons of steel in 1000 miles of the pipe. For long line transportation of oil and gas, such a saving would be of considerable value at the current price of steel and would increase our potential stocks of steel by the tonnage indicated.

(b) In many cases of large quantity production, initial tooling costs may be very high. If, due to inaccurate analysis, a change is required in the production item, hundreds of thousands of dollars of new tooling may be necessary in order to make a relatively simple change in the dimension of a single part.

(c) Let us consider the possibility of transporting military vehicles by air, which may be a requirement in any future conflict, and assume that the transportation of a given military unit requires the use of ten of the large four-engine type C-124 aircraft, each costing approximately $2 million. If, then, by a more accurate design and choice of material of the trucks, jeeps, weapons, and other items to be carried, 25 per cent of their weight could be eliminated, an initial saving of $5 million could be made in the purchase of the transportation equipment in addition to the enormous savings in logistic cost of fuel, maintenance, crew training, and other costs of operation.

A recent review by D. Williams (1)[1] has pointed out a number of the new problems facing the stress analyst interested in aircraft structures, and similar new problems can be found in many other fields. To name a few, high-speed traffic on highways introduces dynamic problems into the design of roadways which must be considered as elastic or semi-elastic slabs on a semi-elastic supporting medium; new designs for tall buildings that will remain structurally intact during earthquakes; and gear designers are being faced with weight, size, and pitchline speed specifications that make it essential that every ounce of material is carrying its proper proportion of the energy that is being transmitted through the system.

THE CHALLENGE OF THE FUTURE

What then are the implications of, and some of the answers to these new concepts? First, and foremost, the stress analyst must realize that these challenges exist in his field and try to prepare himself to meet them. No longer can the designer be satisfied with the simple strength of materials equations with all of their simplifying assumptions and the consequent large "factors of ignorance" which follow. He must be prepared to understand and use the more fundamental equations of classical elasticity, dynamics, and plasticity, and the interrelated fields of aeroelasticity and thermoelasticity. In addition, he must be cognizant of the new materials that have resulted from intensive metallurgical studies in recent years. He must further be prepared to utilize the available tools which will enable him to find the solution to a specific problem that has not as yet been presented in the literature (and there are many such problems).

The tools of the stress analyst can be classed into three major groups, namely: (1) A more exact mathematical approach to the problems of elasticity and plasticity. (2) High-speed computing and analog machines which will enable the stress analyst either to (a) solve mathematical problems beyond the scope of ordinary calculation methods, or (b) investigate a much wider range of the various parameters of a problem in order to more closely approximate that combination of parameters giving the most efficient structure. (3) The use of model testing in order to rapidly investigate the effect of structural changes on the static and dynamic behavior of the composite structure.

Each of the above has its proper place in stress analysis and the tress analyst of the present and the future must be able to use them all in his search for the correct structure.

Above all, the stress analyst must somehow lose his complacent attitude that structural analysis is a routine affair. He must realize that we are now at very much the same point of achievement in the science of structural analysis as was Galileo—many things have been done, but we are confronted with many challenging new problems, the solution to which may very well change the course of the civilization of the future.

REFERENCE

1 "Aircraft Structural Research—A Critical Survey," by D. Williams, APPLIED MECHANICS REVIEWS, vol. 6, no. 8, August 1953, pp. 353–355.

[1] Number in parentheses indicates Reference at end of paper.

Books Received for Review

DUSCHEK, A., Vorlesungen über höhere Mathematik, Bd. III, Wien, Springer-Verlag, 1953, ix + 512 pp. $8.70.

LEIKER, M., Die Gasmaschine, Wien, Springer-Verlag, 1953, ix + 260 pp. $11.45.

BRÜCKNER, H., Gastafeln. Physikalische, Thermodynamische und Brenntechnische eigenschaften des Gase und Sonstigen Brennstoffe, München, R. Oldenbourg, 1952, 222 pp.

SOMMERFELD, A., Vorlesungen über theoretische Physik, Bd. V, Thermodynamik und Statistik, Wiesbaden, Dieterich'sche Verlagsbuchhandlung, 1952, xiv + 374 pp. DM 23.30.

BAŽANT, ZD. ML., Stabilita nekohesních zemin v křivočarém vzestupném proudění, Praha, Nakladatelství Československé Akad. Věd, 1953, 161 pp.

WITTHOFF, J., Die Hartmetallwerkzeuge in der spanabhebenden Formung, München, Carl Hanser Verlag, 1952, 223 pp. DM 16.

WILSON, A. H., The theory of metals, 2nd ed., New York, Cambridge Univ. Press, 1953, vii + 346 pp. $8.50.

HINKLE, R. T., Kinematics of machines, New York, Prentice-Hall, Inc., 1953, vi + 231 pp. $4.75.

PARS, L. A., Introduction to dynamics, New York, Cambridge Univ. Press, 1953, xxii + 501 pp. $6.

SHAPIRO, A. H., The dynamics and thermodynamics of compressible fluid flow, Vol. I, New York, The Ronald Press Co., 1953, xiii + 647 pp. $16.

WANG, C.-T., Applied elasticity, New York, McGraw-Hill Book Co., Inc., 1953, ix + 357 pp. $8.

Letters to the Editor

1. Concerning AMR 6, Rev. 2106 (June 1953): E. M'Ewen, The effect of variation of viscosity with pressure on the load-carrying capacity of the oil film between gear-teeth.

Author did not suggest that film lubrication is only method between gear teeth: object of paper is to examine dependence of film-lubrication load capacity on relative radius of curvature.

E. M'Ewen, England

2. Concerning AMR 6, Rev. 3020 (Oct. 1953): G. Horvay, Thermal stresses in perforated plates.

Reviewer is correct in stating that equality of elastic constants in two perpendicular directions does not insure isotropy. Best illustration is provided by the perforated plate with hole centers arranged on a square grid. Anisotropic behavior of such plates was discussed by this writer in the Closure of K. A. Gardner's paper on "Heat-exchanger tube-sheet design" [*J. appl. Mech.*, p. 572, 1952]. On the other hand, when hexagonal symmetry exists, then isotropy is insured. This was proved in the Closure of the paper, "Stresses in pipe bundles," by H. Poritsky and the writer [ibid., p. 229, 1952]. This then validates the method of the paper in review, as well as of its extensions [ibid., pp. 122, 355, 405, 1952].

G. Horvay, USA

Theoretical and Experimental Methods

(See also Revs. 21, 46, 164, 179, 184, 248, 263, 313, 345)

3. Shortley, G., Use of Tschebyscheff-polynomial operators in the numerical solution of boundary-value problems, *J. appl. Phys.* **24,** 4, 392–396, Apr. 1953.

The finite difference method for the solution of boundary-value problems with elliptic differential equations involves the application of a difference operator over and over again, with the result that the trial solution is improved in every step and converges to the exact solution.

Employment of a Tschebyscheff polynomial cuts down the computing time by a factor of the order of $N^{1/2}$ for two-dimensional and $N^{1/3}$ for three-dimensional boundary-value problems, where N is the total number of points of the net. Author illustrates the method with a simple Poisson equation in two variables with boundary conditions given along a rectangle.

H. G. Loos, USA

4. Guest, P. G., Note on the fitting of polynomials to equally-spaced observations, *J. Math. Phys.* **32,** 1, 68–71, Apr. 1953.

In the fitting of polynomials to equally spaced observations it is customary to employ orthogonal moments calculated from tables of orthogonal polynomials. When the observations are not equally spaced, power moment must be used.

In the present note it is shown that, for the equally spaced case, the method using power moments is as convenient as the method using tables of orthogonal polynomials. The method described is closely related to the method using power moments described by Nielsen and Goldstein [title source, **26,** 120–132, 1947].

The advantage of the present method lies principally in the simplicity of the notation and the use of a model form.

M. Bricas, Greece

5. Woods, L. C., The relaxation treatment of singular points in Poisson's equation, *Quart. J. Mech. appl. Math.* **6,** part 2, 163–185, June 1953.

Author considers the application of relaxation methods to the integration of Poisson's equation $\nabla^2\phi = k(x, y)$ for fields with singular points inside or on the boundary in the following cases: ϕ has finite values but has infinite derivatives; ϕ has logarithmic infinitives; and ϕ has simple discontinuities. Relaxation is the process of reducing certain residuals to zero or near zero with certain approximative values of the left side of the given differential equation. The solution is put in the form $\phi = \varphi + \eta$, where φ is harmonic and η contains the singularity, using quadratic networks. Author derives better numerical results by his method. Applications are given to four examples: Rectangle, capacity of a square section cable, torsion problem, and mapping a circle on a square. The accuracy is comparable with that obtained in similar problems without singularities.

T. Pöschl, Germany

6. Caimann, V., and Hoppe, W., On the calculation of one- and multi-dimensional Fourier series by a mechanical superposition method of new design (in German), *Z. angew. Phys.* **5,** 4, 121–130, Apr. 1953.

For the Fourier synthesis of structure factors of crystals, a mechanical superposition device was developed which is based on the representation of a Fourier series with members of constant amplitudes and of frequency-dependent phase angles. Its essential parts are 14 sine stencils which are traced automatically by return slide rules. The accuracy limited by the precision of the sine stencils is discussed by means of several practical examples. Additional analytic methods are used for multi-dimensional synthesis for which a direct mechanical device would be too expensive and inaccurate.

Margot Herbeck, Germany

7. Weissinger, J., Generalizations of the iteration procedure of Seidel (in German), *ZAMM* **33,** 4, 155–163, Apr. 1953.

The iteration procedure of Seidel, which is used to solve a linear system of equations, provided the matrix of the coefficients is symmetric and definite, is extended to a more general class of iteration procedure and matrix.

The methods outlined are then applied to solve the linear Fredholm integral equation of the second kind.

A. R. Mitchell, Scotland

8. Proceedings of a symposium on industrial applications of automatic computing equipment, Midwest Res. Inst., Kansas City, Mo., 191 pp., Jan. 1953. $4.

These proceedings have several articles which serve as an excellent description of the usefulness of computing machines to engineering design. Desk calculators, analog computers, differential analyzers, IBM punched card, Univac machines are all treated in articles describing the problems of installation, maintenance, and operation of the equipment. A third group of articles gives details of various applications.

In discussing analog computers, the principles of application to control problems are described.

Some of the types of problems discussed in detail, in regard to programming, cost, volume, etc., are: Solution of systems of linear equations, integration of partial-differential equations, distillation-equipment design, gear design. Many other engineering problems are given brief mention.

G. W. King, USA

9. Gürsey, F., Gravitation and cosmic expansion in conformal space-time, *Proc. Camb. phil. Soc.* **49,** part 2, 285–291, Apr. 1953.

The author describes a generalization of Newton's gravitation theory based upon the assumption that the universe is conformal to the space of special relativity. Such a space is completely determined by one scalar function $u(x^1, x^2, x^3, x^0)$, since the line element is

$$ds^2 = u^2[(dx^0)^2 - (dx^1)^2 - (dx^2)^2 - (dx^3)^2]$$

u is assumed to satisfy the single equation obtained by contracting the Einstein field equations of general relativity and is identified with the Newtonian gravitational potential. It is shown that the theory gives only half the observed precession rate of the perihelion of Mercury's orbit. It does not give the bending of light rays in the neighborhood of a massive star, nor does electromagnetic field energy affect the metric tensor. Assuming spatial homogeneity, a cosmical solution is obtained for a universe expanding in agreement, to first approximation, with Hubble's empirical law. This is achieved by allowing matter to be created continuously. G. Salzman, USA

10. Bennett, G. E., and Richards, G. R., Electronics applied to the measurement of physical quantities, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2627, 124 pp., Sept. 1947, published 1953.

The report describes the application of electromechanical and electronic principles to the design of instruments for the measurement of physical quantities such as movement, strain, pressure, acceleration, and vibratory motion, with particular reference to the special requirements of aeronautical engineering. The dynamic characteristics of pickups are considered and subdivided on an electrical basis into electromagnetic, capacitance, and resistance types, a detailed description of each type being given. This is illustrated by a historical survey of their development and by reference to a number of various recent designs and their characteristics. Piezoelectric, magnetostrictive, photoelectric, hot-wire, vibrating wire, and vacuum-tube pickups are also considered briefly, and reference is made to calibrating devices and techniques.

An account is given of the circuits used for the conversion of the electrical variation produced in each type of pickup into a corresponding voltage or current, particular mention being made of bridge circuits and resonance-circuit methods. The special requirements of amplifiers and the best basic circuits for satisfying them are considered and illustrated by detailed reference to a number of particular amplifier designs; in particular, direct-coupled and carrier amplifiers are considered.

The requirements of recording equipment and the various recording methods are discussed and a detailed account given of photographic recording and various oscillograph cameras, their optical arrangements, components, and timing devices. Single and multichannel recording equipments are considered with a brief survey of existing literature and more detailed reference to new developments of single-channel equipments designed for specific purposes, and four-, six-, and twelve-channel general-purpose equipments using either cathode-ray tubes or recording moving-coil galvanometers.

Finally, the application of the techniques and instruments to typical measurements undertaken since 1940 are described in order to illustrate the type of work which may be undertaken by such methods and the form and nature of the results obtained.

From authors' summary

11. Tables of normal probability functions, U. S. Dept. Comm., Nat. Bur. Stands., Appl. Math. Ser. no. **23,** 344 pp., June 1953. $2.75.

Present volume (3rd edition) tabulates the function $(e^{-x^2/2})/(2\pi)^{1/2}$ and its integral. These are of fundamental importance in statistics and many other applied fields. Y. Luke, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 23, 57, 189)

12. Grinter, L. E., Engineering mechanics, New York, Macmillan Co., 1953, xix + 408 pp. $5.75.

Engineering mechanics is fundamental to every student who aspires to be an engineer. Far too few texts possessing unity in thought, along with simplicity in expression, are available to the sophomore student. This book is such a treatment and it will help fulfill a definite need.

The subject matter is adequately covered in 14 chapters following the logical sequence of first introducing statics, then, before proceeding with dynamics, a chapter on moments of inertia and then the dynamics section followed by a chapter on virtual work.

The six chapters on statics deal first with basic concepts followed by coplanar force systems, equilibrium of bodies, and applications to structures and machines involving friction. The last chapter of this section introduces the student to force systems in space. The presentation is quite clear and in sufficient detail.

The seventh chapter serves a twofold purpose: Besides covering the subject of moments of inertia of areas and bodies, it acts as a demarcation between the static and dynamic sections of the text. The chapters constituting the dynamic section cover plane kinematics and kinetics or, more precisely, motion of particles and rigid bodies, and the relation between the forces on a body and the motion of the body. This includes mass acceleration, work and energy, and impulse and momentum.

Unlike many similar texts, two additional chapters discussing vibrations and the principle of virtual work are included; however, no attempt is made to develop these topics beyond the elementary stage, and their usefulness is questionable.

The author has done an admirable piece of work. The abundance of numerical examples and clear explanatory diagrams is commendable. Moreover, if the student will read and then "soak in" the enlightening thoughts of the preface and foreword, a sincere service will have been performed by the author.

G. B. White, USA

13. Lohr, E., Mechanics of solids [Mechanik der Festkörper], Berlin, Walter de Gruyter & Co., 1952, viii + 483 pp., 73 figs. DM 39.60.

Professor Lohr's death prevented completion of a proposed three-volume Lehrbuches der Physik. However, publication was accomplished for the first volume which is devoted to mechanics of solid bodies. The general treatment of this work is in the classic German tradition for presenting texts on mathematical physics. While technological motivation is mentioned in the foreword, the text is essentially a mathematical treatment of standard material on the mechanics of bodies, both rigid and deformable.

Approximately one half of the book is devoted to vector and dyadic theory as well as principles of mechanics and application to the motion of solid bodies. A chapter on principles of dynamics includes Lagrangian equations of motion and the Hamiltonian principle. This theory is satisfactorily presented but is not extensive in theoretical content and, in this sense, may have been construed as appropriate for use on many technological problems.

The second half of the book consists of mechanics of deformable solids, including vibrations of discrete systems as well as vibrations of rods, beams, and plates. There is a treatment of elastic vibrations in two and three dimensions, including wave propagation with a study of reflection and refraction. The elements of the mathematical theory of linear elasticity are carefully developed in Cartesian coordinates using dyadic representation and analysis. There is an extension to plasticity and strength theory, both of which are treated in a single chapter. The last chapter of the book is a study of the familiar problem of impact, illustrated by the collisions of elastic bodies with some elementary consideration of rotation and of friction.

There are very few illustrative problems, especially in connection with the classical theory of elasticity. Such a treatment of classical theory is more in line with the brief casual approach of the modern physicist to these subjects than what is needed for applied mechanics.

The physical aspects of the book are quite satisfactory, with excellent format and good printing. There is an abundance of pertinent references distributed throughout the book in the form of footnotes. Those in connection with plasticity concern much of the material of the past decade. W. H. Hoppman II, USA

14. **Graffi, D., On the problem of two bodies with variable mass** (in Italian), *Ann. Univ. Ferrara*, Ser. VII (N.S.) **1**, 23–33, 1952.

This paper is a continuation of some previous papers by the same author [*Atti Accad. Sci. Torino* **68**, 262–272, 459–482, 1932; *R. C. Accad. Naz. Lincei* (6) **12**, 144–151, 228–233, 1934; *Ann. Mat. pura appl.* (4) **15**, 87–128, 1936]. A new upper bound is determined for the variations of the eccentricity of the osculating orbit in the problem of two bodies with variable masses. This new upper bound is found to be particularly suitable in the case of small eccentricities. In addition, a confirmation of a previous theorem to the effect that small variations of the eccentricity are not incompatible with large variations of the masses, is obtained. E. Leimanis, Canada

15. **Volpato, M., An observation on the approximate solution of the problem of two bodies with variable masses** (in Italian), *Ann. Univ. Ferrara*, Ser. VII (N.S.) **1**, 35–46, 1952.

An approximate solution is given for the so-called reduced problem of two bodies with variable mass [cf. Armellini, *R. C. Accad. Naz. Lincei* (6) **25**, 297–301, 1937]. This is the case where it is assumed that the eccentricity of the osculating orbit is infinitely small. Making use of a recent result obtained by Graffi (see preceding review), it is shown that in the astronomical case (when the total mass varies slowly with the time) the approximate solution obtained differs little from the exact solution and holds under less restrictive conditions than the approximate solution obtained by Michelacci [*Pont. Acad. Sci. Comment.* **13**, 1–12, 1944], using a different method. This result also confirms the legitimacy of replacing the equation governing the motion of two bodies with variable mass with the equation of Armellini in the case of the reduced problem. E. Leimanis, Canada

16. **Manacorda, T., The motion of a body with variable mass** (in Italian), *Riv. mat. Univ. Parma* **3**, 361–373, 1952.

The study of the dynamics of rockets has directed serious attention to the motion of a body with variable mass. J. B. Rosser, R. R. Newton, and G. L. Gross ["Mathematical theory of rocket flight," New York, McGraw-Hill Book Co., Inc., 1947] have based their treatment of rocket motion on two relations which are substantially the cardinal equations of motion for a body with variable mass. In the paper under review these cardinal equations are derived in a different but rigorous way. The new derivation of the second equation is considerably shorter than that given by Rosser, Newton, and Gross. These equations are applied to a simple case of rocket motion in a vacuum where the rocket's axis of revolution coincides with the z-axis of the moving trihedral for the duration of the motion. E. Leimanis, Canada

17. **Schy, A. A., A theoretical analysis of the effects of fuel motion on airplane dynamics,** *NACA Rep.* 1080, 22 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 2163.

18. **Raškovic, D., Mechanics. II. Kinematics [Mekhanika. II. Kinematika]**, Beograd, Izd. Preduz. Narod. Repub. Srbije, 1950, 288 pp.

The second edition of this book is similar to the first edition, but many details of the text have been improved by revision.

The entire book is divided into two parts and an appendix. Part 1, which treats the kinematic of a point, contains an introduction to the equations of motion, velocity, and acceleration and their representation in the more common coordinate systems. Part 2 describes the motion of a rigid body rotating about a fixed axis and deals with the Eulerian concept of motion, gyroscopic effect, Cardano's problem, general and relative motion of a solid body.

The appendix contains necessary elements of vector analysis for application to the differential geometry and proceeds through field theory; this treatment is the weakest section of the text. The entire book contains 97 sample problems complete with their solutions.

The treatment of topic is classical, with no original methods presented in the book. The development of the subject matter provides maximum clarity for the reader and maintains high pedagogical standards. M. M. Stanišić, USA

Gyroscopics, Governors, Servos

(See also Rev. 272)

19. **Lauer, H., Operating modes of a servomechanism with non-linear friction,** *J. Franklin Inst.* **255**, 6, 497–512, June 1953.

A simple positioning servo containing Coulomb and viscous friction is idealized to the extent that it may be represented by a second-order equation of motion. Responses to various input step velocity functions are indicated graphically, both in phase and ordinary time planes, and it is demonstrated that these responses are dependent on magnitude and manner of application of the step functions, either quiescent or limit cycle operation being possible. Two forms of the friction function are considered, one of which contains a sudden decrease in friction upon incidence of motion, and the other a more gradual decrease to a minimum value at a low speed.

A typographical error exists in Eq. (3) where coefficient J should multiply the second derivative of Θ instead of the first derivative. L. Becker, USA

Vibrations, Balancing

(See also Revs. 13, 81, 116, 121, 134, 353)

20. **Wait, J. R., An approximate method of obtaining the transient response from the frequency response,** *Canad. J. Technol.* **31**, 6, 127–131, June 1953.

An approximate method for determining the transient response of a system whose steady-state response characteristics are known

is given with particular applications for the case where the real frequency function is linear or approximated by a series of straight lines when plotted against a log frequency base. Examples are given for a function $Z(iw)$ whose time function is known, as well as a function $Z'(iw)$ which has a simple pole.

J. B. Duke, USA

21. Chenea, P. F., On the application of the impedance method to continuous systems, *J. appl. Mech.* **20,** 2, 233–236, June 1953.

See AMR **6,** Rev. 2157.

22. Giangreco, E., On a theoretical and experimental investigation of a problem of dynamic instability, (in Italian), *G. Gen. civ.* **91,** 4, 181–187, Apr. 1953.

The problem of elastic stability of a system subjected to a transverse pulsating force is investigated. The critical frequency of the external force is determined, using the hypothesis of essentially linear stress-strain relationships. Reference to experimental investigations made at the Istituto Nazionale dei Motori is made, and it is emphasized that the experimental evidence agrees excellently with theoretical predictions.

From author's summary by M. A. Dengler

23. Crossley, F. R. E., The forced oscillation of the centrifugal pendulum with wide angles, *J. appl. Mech.* **20,** 1, 41–47, Mar. 1953.

Present paper is the third in a series by author. The first one considered the use of hyperelliptic functions in nonlinear vibration problems [AMR **5,** Rev. 2282]; the second discussed free nonlinear vibration of centrifugal pendulum [AMR **6,** Rev. 1180].

Exact equations of motion are derived, assuming periodic torque acts as rotating carrier. Author does not assume, however, that angular velocity of carrier is constant. As a result, motion of pendulum is expressible in hyperelliptic functions. Successive approximation procedure is suggested for determining complete forced motion.

Resonance curves are determined for steady-faced motion, assuming simple harmonic excitation and hyperelliptic motion for pendulum. The design problem is considered. Author concludes that pendulums should have shorter length than given by linear theory.

J. L. Bogdanoff, USA

24. Federhofer, K., Frequency equation of transverse vibrations of a triple supported beam with a concentrated and a uniformly distributed mass (in German), *Öst. Ing.-Arch.* **7,** 1, 26–32, 1953.

Frequency equation is deduced in exact (implicit) form. For numerical solution, Dunkerley's method is used to find first approximation of unknown frequency, and accurate numerical solutions are then obtained by trial and error.

Two limiting cases are treated: (a) Simply supported beam with uniformly distributed and one concentrated mass; (b) one end fixed and one simply supported mass as in (a). Formulas obtained are correct, although reasoning in case (a) is incorrect. Reviewer believes that this case cannot be deduced as a special case of author's equations.

F. I. Niordson, Sweden

25. Traill-Nash, R. W., and Collar, A. R., The effects of shear flexibility and rotatory inertia on the bending vibrations of beams, *Quart. J. Mech. appl. Math.* **6,** part 2, 186–222, June 1953.

Authors give solution to Timoshenko equation (title problem for uniform beams) in implicit form. There is a considerable discussion of the nature of the frequency spectra, including a "second" spectrum which occurs with high frequencies or high rotatory inertia [AMR **6,** Revs. 2703, 2704]. This is associated with rotation opposite to that of elementary beam theory. Authors show importance of shear terms in modern box beams. They show very good agreement with experiments on a beam constructed to conform to their assumptions. Some calculations on a typical wing structure indicate serious error in the frequencies of the higher modes due to neglecting shear flexibility. These calculations were numerical and involved the usual lumped parameter approximation.

R. Plunkett, USA

26. Rosard, D. D., Natural frequencies of twisted cantilever beams, *J. appl. Mech.* **20,** 2, 241–244, June 1953.

See AMR **6,** Rev. 2158.

27. Dzung, L. S., Influence matrix of beam vibration, *J. aero. Sci.* **20,** 6, p. 437, June 1953.

Note in Readers' Forum.

28. Friedlander, F. G., On the oscillations of a bowed string, *Proc. Camb. phil. Soc.* **49,** part 3, 516–530, July 1953.

Author considers the small transverse oscillations of a string excited by bowing. The ends of the string are assumed fixed and the bow is replaced by a concentrated force acting transversely at the bowing point. Nonlinear recurrence equations for the velocity are obtained which prove too difficult to solve. Instead, some of the possible periodic motions of the string are considered. Author's theory predicts that a "noise" instead of a note is produced for small bowing speeds. According to the author, this phenomenon seems not to have been noted in the literature.

E. J. Scott, USA

29. Lazan, B. J., Effect of damping constants and stress distribution on the resonance response of members, *J. appl. Mech.* **20,** 2, 201–209, June 1953.

See AMR **6,** Rev. 1812.

30. Arnold, R. N., and Warburton, G. B., The flexural vibrations of thin cylinders, *Instn. mech. Engrs. Proc.* (*A*) **167,** 1, 62–74, 1953.

Frequencies for the flexural vibrations of the walls of thin circular cylinders are determined theoretically for supported and fixed conditions at the cylinder ends. Experimental values of frequencies are obtained for varying amounts of end fixity. An empirical relation in terms of equivalent longitudinal wave length is established so that the frequency curves for supported cylinders can be used to determine comparable values for cylinders with partially fixed ends.

Theoretical values of frequency are determined by assuming longitudinal and circumferential mode patterns that satisfy the end conditions. The frequencies corresponding to these modes are determined by means of Rayleigh's principle. The measured and calculated frequencies are in close agreement.

M. V. Barton, USA

31. Bendixen, I., Vibrations in knee-type horizontal milling machines, *Trans. ASME* **75,** 4, 567–572, May 1953.

Specimens of mild steel were solidly bolted to the tables of horizontal knee-type milling machines of either Wanderer or Biernatzki design, and vibrations developed in dry milling of them were determined by a capacitive pickup mounted on the milling table. Milling was done under conventional operating conditions and either having the knee unclamped from the column, saddle unclamped from the knee, or the overarm unclamped from the column. Greater rigidity of the assembly leads to a lower ampli-

tude of vibrations when resonance is not involved. The knee system of any conventional knee-type milling machine has a number of natural frequencies which, however, will not produce vibrations unless the cutter passes directly over the clamping bolts. Then they cause serious vibrations. A resonant section can be effectively shifted out at low speeds by changing either the velocity or the number of teeth of a cutter, and, to a lesser extent, by changing the feed and width or depth of cut. Torsional moments induced by cutting forces cause force concentration at the edges of supporting prisms of the machine elements producing a certain amount of deflection, the extent of which is independent of the length of the supporting prism. They form a kind of elastic support, which, unless dampened by friction, increases the amplitude of vibrations. Avoiding this deflection by increased rigidity of the setup under operating conditions is basically important for good performance. J. D. Gat, USA

32. Klein, A. M., and Crockett, J. H. A., Design and construction of a fully vibration-controlled forging hammer foundation, *J. Amer. Concr. Inst.* **24,** 5, 421–444, Jan. 1953.

To eliminate the ground vibration from an 8-ton forging hammer and to provide against fatigue failure of the foundation, extensive precautions were taken. Shock waves upon reflection tend to set up dangerous tension stresses in the concrete. To prevent a fatigue failure, the lower block was prestressed in all three dimensions with a series of Freyssinet cables. To secure a homogeneous upper block, in spite of the very dense reinforcement pattern, grouted (Prepakt) concrete was used which gave 7250-psi strength at 90 days. Construction procedure is shown in excellent pictures.

The foundation was fully analyzed for shock and vibrations. The lower block is placed on removable helical springs, with friction dampers. The 160-ton upper block is mounted on four massive legs to provide access space to side-controlling springs and dampers. Rubber springs are used under the anvil, with provisions for water-spray cooling. Vibrograph readings are reported to have checked the initial calculations closely.

This is a very massive but very intricate installation.

P. M. Ferguson, USA

Wave Motion, Impact

(See also Revs. 32, 47, 186, 246, 343)

33. Mindlin, R. D., and Bleich, H. H., Response of an elastic cylindrical shell to a transverse, step shock wave, *J. appl. Mech.* **20,** 2, 189–195, June 1953.

This paper describes a mathematical study of the response of an infinitely long, elastic, homogeneous shell of circular cross section submerged in an acoustic fluid when a plane shock wave is incident upon the shell, the axis of which is parallel to the wave front. By an approximation which may be expected to be good during the early stages of envelopment, the potential of the diffraction and radiation is eliminated and a simple differential equation obtained for each generalized coordinate describing the motion of the shell. While this equation may be solved for quite general shock-wave properties, the discussion is limited to a step shock wave in order to minimize the computations required. For the purely dilatational mode of vibration, the solution is obtained in terms of incomplete modified Bessel functions of the first kind and evaluated by numerical integration; explicit expressions for the displacement, velocity, pressure, and acceleration are given as functions of the time t and illustrated by typical graphs; all the results approach the correct limits for large values of t, despite the apparent limitation of the method of solution to short times. The translational mode is handled in like manner. In the case of the flexural modes, expressions for the stress, velocity, pressure, and acceleration are deduced and plotted for typical cases, and the phenomenon of flexural instability is discussed.

R. Heller, USA

34. Bishop, R. E. D., On dynamical problems of plane stress and plane strain, *Quart. J. Mech. appl. Math.* **6,** part 2, 250–254, June 1953.

Author shows that in a homogeneous isotropic medium the equations of motion for plane stress (excluding that for zz) are identical with those for plane strain, the only difference being that of elastic constants. Similar potential functions as used for plane strain problems can be found for problems of plane stress.

An illustrative problem in both plane stress and plane strain of symmetrical waves in an infinite plate is discussed, and, as expected, the dispersion equation in either case is found to be of the same type.

S. C. Das, India

35. Satô, Y., Study on surface waves. II. Velocity of surface waves propagated upon elastic plates, *Bull. Earthq. Res. Inst., Tokyo* **29,** 2, 223–261, June 1951.

The propagation of waves in an infinite elastic plate is discussed, and, in particular, some numerical results of H. Lamb [*Proc. roy. Soc. Lond.* (*A*) **93,** p. 114, 1913] are extended. The problem when the plate is supported on a liquid of either finite or infinite depth is also discussed with application to the analysis of seismograms recorded from the movements of lake ice sheets.

H. G. Hopkins, USA

36. Satô, Y., Study on surface waves. III. Love-waves with double superficial layer, *Bull. Earthq. Res. Inst., Tokyo* **29,** 3, 435–444, Sept. 1951.

Problem has previously been investigated by Matuzawa, Stoneley and Tilotson, and Menzel. With reference to these papers, author discusses general theory of Love waves with double surface layer. He formulates the condition of existence of these waves thus: "The velocity of the lowest medium is not the smallest of three values corresponding to the three media," and draws dispersion curves for various cases.

W. Freiberger, Australia

37. Satô, Y., Study on surface waves. IV. Equivalent single layer to double superficial layer, *Bull. Earthq. Res. Inst., Tokyo* **29,** 4, 519–528, Dec. 1951.

Paper concerns the propagation of Love waves in a composite system consisting of two finite layers resting on a semi-infinite layer. Author shows that it is unsatisfactory to approximate the system by a substitute system consisting of one finite layer resting on a semi-infinite layer. All layers are homogeneous, isotropic, and elastic.

In reviewer's opinion, the author's substitute system might well be expected to prove unsatisfactory as a representation of the original system for the reason that the latter's heterogeneity is too greatly simplified. Indeed, it seems reasonable to suppose that any useful substitute system must be expected to possess a degree of heterogeneity which is least comparable to that of the substitute systems employed by R. Stoneley [*Mon. Nat. roy. astro. Soc., Geophys. suppl.* **3,** 222–232, 1934] and M. Newlands [ibid., *suppl.* **6,** 109–124, 1950]. Moreover, recent work by M. Newlands [*Phil. Trans. roy. Soc.* (*A*) **245,** 213–308, 1952] on the generation of surface waves indicates the need for further work on the effects of heterogeneity.

H. G. Hopkins, USA

38. Satô, Y., Study on surface waves. V. Love-waves propagated upon heterogeneous medium, *Bull. Earthq. Res. Inst., Tokyo* **30,** 1, 1–11, Mar. 1952.

Author considers plane periodic waves of Love type for semi-infinite medium whose rigidity varies linearly with depth. Solution is expressed by means of confluent hypergeometric functions. Solution is then obtained for case of such a medium above which lie two strata, each being homogeneous, of equal density and thickness but of different rigidity. Numerical results and curves are presented for phase and group velocities as a function of the wave period. For three special wave lengths, the amplitude is plotted as a function of depth in both layers and the substratum.

H. J. Plass, USA

39. Satô, Y., Study on surface waves. VI. Generation of Love and other types of SH-waves, *Bull. Earthq. Res. Inst., Tokyo* **30,** 2, 101–120, June 1952.

Two reciprocal formulas are derived for the case of propagation of SH-waves in a semi-infinite medium overlaid by a layer. They represent relationships between displacements at any one of two points if a source is placed at the other point. The expressions for disturbances in SH-waves are obtained by usual methods, but the evaluation of an integral representing the refracted waves is subjected to a more precise analysis. Conditions are given for the Love waves having the amplitudes decreasing as x^0 (x is distance), for predominant SH-waves ($x^{-1/2}$) and for ordinary SH-waves ($x^{-3/2}$). In the contour integral, no term was found which could represent the reflected waves. Several tables and figures for amplitude distribution of Love waves conclude the paper.

W. S. Jardetzky, USA

Elasticity Theory

(See also Revs. 13, 22, 33, 34, 47, 48, 49, 50, 51, 59, 60, 61, 62, 65, 66, 69, 74, 91, 93, 111, 128, 141, 143, 144)

40. Krettner, J., The fundamental equations of elasticity theory in generalized curvilinear coordinates (in German), *Öst. Ing.-Arch.* **7,** 1, 11–21, 1953.

Author attempts to derive the general equations of elasticity theory by means of the tensor calculus without considering the equilibrium of volume elements.

In section 2, the development of the line element is given, i.e., the metric tensor g_{ik} is derived. The development parallels that given in Stratton's "Electromagnetic theory," and so no new ideas are introduced here. Section 3 concerns the derivation of the strain tensor in general curvilinear coordinates; the treatment here parallels the one in Ollendorf, "Welt der Vektoren," 1950. Section 4 considers the stress tensor and the associated stress quadric. Section 5 treats the equilibrium of the medium, i.e., the equations of equilibrium in curvilinear coordinates. The derivation depends upon the form of the equilibrium equations in a Cartesian system and, hence, using the invariant concept of the laws of physics, the structure of the equations is given for general coordinates. Here, as in the previous sections, the Christoffel symbols enter into the relations. Section 6 exhibits the relation between stress and strain, the usual one, for an isotropic medium only. Sections 7, 8, 9, 10 are devoted to the development of the form of the Laplace operator for curvilinear systems, cylindrical, spherical, etc., and its use in obtaining the relations for these systems.

Although the author does use tensor calculus in his development, he has not used the summation convention. Reviewer does not find anything new or novel in this paper, and, in so far as a tensor treatment of the subject is concerned, there are far more elegant and clearer discussions on this subject. To mention a few, L. Brillouin, "Les lois de l'élasticité sous forme tensorielle valable pour des coordonnées quelconques," *Ann. Phys.* **3,** 1925; F. D. Murnaghan's classic paper, "Finite deformations of an elastic solid," *Amer. J. Math.* **59,** 1937; and for further reference see F. S. Sokolnikoff's text, "Tensor analysis," Wiley, 1951, and also his "Mathematical theory of elasticity," McGraw-Hill, 1946 (see references contained therein).

J. J. Brandstatter, USA

41. Föppl, L., Example of the mean value theorem of two-dimensional elasticity (in German), *ZAMM* **33,** 4, 127–130, Apr. 1953.

Author establishes that if a hole, whose size is small compared to its distance from the edges of the plate, is made in a plate submitted to forces acting on the outer boundaries only, the average value of the stresses along the edges of the hole equals the average value of the sum $\sigma_x + \sigma_y$ of the stresses across the normal section remaining between edges of plate and hole.

This theorem can be checked analytically for circular and elliptic holes, as the solutions in those cases are known. In this article, the author deals with photoelastic verification for the case of a hole the edge of which consists of circumference arcs and straight lines, working for rapidity's sake only with fringe order instead of calculating stresses.

The theorem, in the reviewer's opinion, may be applied profitably in photoelasticity.

A. M. Guzmán, Argentina

42. Sherman, D. I., On the question of the state of stress of a mountain mass between two excavations. Elastic massive medium weakened by two elliptic holes. II (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. **7,** 992–1010, July 1952.

Continuation of earlier paper [AMR **6,** Rev. 2468]. Discussion is highly technical; mathematical and complex functions are used throughout. Results for the stresses are given in tables and in graphs.

D. ter Haar, Scotland

43. Smith, J. O., and Liu, C. K., Stresses due to tangential and normal loads on an elastic solid with application to some contact stress problems, *J. appl. Mech.* **20,** 2, 157–166, June 1953.

See AMR **6,** Rev. 1834.

44. Kaar, P. H., A method of obtaining shear stress-strain graphs by interpretation of moment-twist data, *Trans. ASME* **75,** 4, 521–523, May 1953.

This paper shows shear stress-strain curves of SAE 4340 and 1045 steels obtained from the moment-twist data of circular shafts. Upper and lower yielding points are shown in the 4340 steel curve.

T. H. Lin, USA

45. Weinberger, H. F., Upper and lower bounds for torsional rigidity, *J. Math. Phys.* **32,** 1, 54–62, Apr. 1953.

Minimum principle is developed which establishes bounds on the torsional stiffness of sections compounded of elemental sections whose stiffnesses are known. A lower bound of the combination is obtained as the sum of the elementary stiffnesses. An upper bound for sections with holes is obtained if the stiffness of holes is subtracted. For sections with holes, a more accurate lower bound is obtained by subtracting from the stiffness of the full section the stiffness of a subsection which contains the hole but is itself contained in a contour line of the stress function of the full section. Some bounds for a number of sections with holes are given.

J. E. Duberg, USA

Experimental Stress Analysis

(See also Rev. 75)

46. Acharya, Y. V. G., Srinath, L. S., and Lakshminarayana, C. N., Evaluation of stresses in a circular ring by the relaxation method, *Appl. sci. Res.* (*A*) **3,** 6, 415–428, 1953.

Paper uses photoelastic model analysis and relaxation technique to determine stresses in circular ring loaded in compression by concentrated loads at opposite ends of a diameter. Analysis is quite straightforward but provides interesting example of combination of two techniques. Photoelastic technique is used to determine difference of principal stresses at a number of points; relaxation method determines their sum. Solution of two equations at each point determines individual stresses. Advantage is that only the simplest photoelastic equipment is required.

F. A. Blakey, Australia

47. Rinehart, J. S., and Pearson, J., Engravement of transient stress wave particle velocities, *J. appl. Phys.* **24,** 4, 462–469, Apr. 1953.

High-intensity transient stress waves of a few microsec duration were set up in metal plates by detonation of explosives in contact with one side of the plates. A small metal pellet, a cylinder of uniform thickness, was placed with its flat side in contact with a plate on the side opposite from the explosive charge. The depth of the permanent imprint of the pellet on the plate is related to the particle velocity associated with the stress wave. It is desired to obtain quantitative information as to the nature of the transient wave by means of imprint depth determinations for different pellet sizes. Quantitative verification of the technique consisted of using depth of engravement and pellet throw-off velocity to determine independently the known velocity of propagation of the compressional wave in the plate. Velocity values determined agree reasonably well with accepted values.

I. Vigness, USA

Rods, Beams, Shafts, Springs, Cables, etc.,

(See also Revs. 24, 25, 26, 27, 78, 103, 104, 105, 106, 139)

48. Volterra, E., and Chung, R., Bending of a constrained circular beam resting on an elastic foundation, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 205, 12 pp., July 1953.

The solution of the problem of a circular beam resting on an elastic foundation, loaded by concentrated symmetric forces and constrained in such a way that the sections where the vertical loads are applied cannot rotate, is given in explicit form. Tables for the deflections, angles of twist bending, and twisting moments are presented.

From authors' summary by C. B. Biezeno, Holland

49. Volterra, E., Deflections of circular beams resting on elastic foundations obtained by methods of harmonic analysis, *J. appl. Mech.* **20, 2,** 227–232, June 1953.

Paper extends a previous work by the same author [AMR **5,** Rev. 1327] in which solutions in closed form were obtained for symmetric loads only. Present paper obtains solutions in form of Fourier series for both symmetric and antisymmetric load components. Series solutions are given for beam deflection, angle of twist, bending moment, and twisting moment. Coefficients in the series depend upon two dimensionless parameters, μ and λ, which are determined by properties of the beam and stiffness of the foundation. Numerical values for the coefficients of the first 24 terms are given for two pairs of values for μ and λ.

W. C. Hurty, USA

50. Sadowsky, M. A., and Sternberg, E., Pure bending of an incomplete torus, *J. appl. Mech.* **20,** 2, 215–226, June 1953.

Authors consider a curved beam in the form of a segment of a torus of circular cross section that is bent in the plane of its centroidal axis by couples applied at the ends. Timpe's general axisymmetric torsion-free solution of the equations of the classical small-displacement theory of elasticity is modified and adapted to the boundary conditions of the problem. The method leads to an explicit solution in the form of an infinite series that is naturally quite involved, in view of the intrinsic difficulties in the problem. As a numerical example, the stresses are calculated for a beam for which the radius of the centroidal axis is five times the radius of the cross section. The hoop stress at the inner periphery is found to be about 10% greater than that determined by the Winkler-Bach theory or by the more elaborate theory of Göhner.

H. L. Langhaar, USA

51. Green, A. E., and Wilkes, E. W., A note on the finite extension and torsion of a circular cylinder of compressible elastic isotropic material, *Quart. J. Mech. appl. Math.* **6,** part 2, 240–249, June 1953.

A circular compressible cylinder is given a finite extension increasing its length in the ratio $\lambda:1$ and then a twist ψ per unit length so that plane sections perpendicular to the axis remain plane sections. The strain-energy function has a completely general form in terms of the three invariants of strain and the solution is developed as a power series in ψ. The ratio of the radii of the strained and unstrained cylinder and the longitudinal forces required to maintain the extension and twist are found in series as far as the terms in ψ^2, while the axial couple necessary to produce the twist is given as far as the term in ψ^3. The special case in which the longitudinal force is zero is also considered, and the resulting extension ratio λ is evaluated in the case for a given ψ.

From authors' summary by J. M. Klitchieff, Yugoslavia

52. Eshelby, J. D., Screw dislocations in thin rods, *J. appl. Phys.* **24,** 2, 176–179, Feb. 1953.

In an attempt to explain experimental results of Galt and Herring on thin whiskers of tin [AMR **5,** Rev. 3401], author assumes a screw dislocation in rod parallel to axis and studies behavior of rod in torsion and bending. Rough agreement exists between theoretical bending strain and that found experimentally for occurrence of permanent strain. Important conclusion of paper is that a screw dislocation within a certain maximum distance from the center of the rod will not tend to move outward by itself. A certain critical twisting moment or bending deflection is necessary to cause outward movement with accompanying permanent strain. Hence, increased strength of Galt and Herring's tin whiskers does not indicate absence of dislocations.

H. J. Plass, Jr., USA

53. Inan, M., Shear center of semi-elliptical cross section, *Bull. tech. Univ. Istanbul* **4,** 1, 25–28, 1951.

The location of the shear center for a semi-elliptical cross section is determined by the use of Trefftz' method. Author states that the result in the peculiar case of a semi-circular section does not agree with a formula given by Timoshenko ["Theory of elasticity" and "Theory of bending, torsion, and buckling of thin-walled members of open cross section," *J. Franklin Inst.* **239,** 1945].

Reviewer established the fact that the formula of Timoshenko is also not in accordance with the location of another shear center as defined by W. T. Koiter ["The torsional center of beams, loaded by shearing forces," Verslagen en verhandelingen van het Nationaal Luchtvaartlaboratorium Amsterdam, **VIII,** 1939].

R. J. Legger, Holland

54. Weber, C., and Banaschek, K., Stress distributions in the teeth of spur gears and helical gears in relation to the geometrical characteristics of the profile [Formänderung und Profilrücknahme bei gerad- und schrägverzahnten Rädern], Braunschweig, Friedr. Vieweg & Sohn; Schriftenreihe Antriebstechn. Heft 11, 88 pp., 1953.

The theoretical studies and investigations presented in this work deal with the determination of the elastic deformation of teeth and their adjacent parts of straight and helical spur gears. While the gears are in mesh and under load, the deformations are calculated with consideration of the following factors: At the point of contact, Hertz equations are used to determine the flattening effect of contact pressure; then the deformations due to bending moment and normal and tangential forces are considered.

The calculation of the deformation is extended to the bottom land and its adjacent portion. The corrections of the contour of the face at the top land for straight and helical spur gears are calculated and listed. The work consists of six reports representing a lucid procedure of derivations of all equations used and a number of calculations and contains numerous diagrams, sketches, and tables. It is an excellent work and many results obtained are original in conception. W. Ornstein, USA

55. Heyer, E., Experimental investigations concerning cyclindrical worm gear systems [Versuche an Zylinderschneckentrieben], Braunschweig, Friedr. Vieweg & Sohn; Schriftenreihe Antriebstechn. Heft 10, 144 pp., 1953.

The results of investigations are presented, and experiments and tests which were made in the course of study of a number of worm gears at the Technische Hochschule in München are described. The worm gears are analyzed to establish the influence of the material of mating gears, of the surface condition of the teeth, of the velocity of gears, and of the kind and viscosity of oil on the frictional coefficient at the tooth flanks.

The aim of the study is to find the favorable conditions influencing the transmitted power and the decrease in power loss in worm gears. Further, investigations were conducted to determine how the number of revolutions per minute and the oil viscosity influence the transmitted power, the power loss, and the cooling capacity of the housing.

A number of photographs, diagrams, and sketches accompany this extensive study on worm gears. W. Ornstein, USA

56. Heumann, H., On the calculation of corrected involute gears (in German), *Maschinenbau-Technik* **2**, 3, 101–107, Mar. 1953.

Paper shows how the contact pressure, the specific sliding, and the contact ratio of a meshing pair of involute gears are influenced by correcting the latter. Formulas are derived for these values, and charts are developed to simplify the use of lengthy terms. Another article on the relation between the bending strength and the correction of involute teeth is contemplated. The work offers help to the gear designer in checking the required amount of correction for maximum load with a relatively small calculation effort. The very important dynamic load conditions are not dealt with. J. Boehm, USA

57. Nikitin, A. A., Determination of the efficiency of differential gear systems by means of the force exchange method (in German), *Maschinenbau-Technik* **2**, 3, 116–119, Mar. 1953.

Author uses a method given by L. N. Reschetow for planetary gear systems ["Planetary gear systems," ESM, 1948, vol. 2]. Method takes into account the radii (and number) of teeth, the fact of externally or internally toothed wheel, the relative position of all forces acting upon the planetary block, including the centrifugal force acting upon it. The method used considers the losses caused by friction in gear systems by transferring the acting forces to reduced levers. Author refers to a "reciprocal method" for determination of the coefficient of efficiency without giving any details concerning this method.

The German translation of the Russian original reviewed here shows a drawing with lettering which is not in accordance with the text. The list of signs used, as given at the beginning of the article, is not in agreement with those in the drawing.

A. Slibar, Austria

58. Beckers, P., Calculation methods for the layout of gear triangles (in German), *Maschinenbau-Technik* **2**, 1, 11–17, Jan. 1953.

The task of driving three spur gears by means of one gear, which is centrally arranged, is investigated. The distances between the centers of the driven gears are given. By considering the required pitch of the gears, the following cases are treated: (a) To verify prescribed ratios between the driving shaft and the driven shafts as closely as possible; (b) to determine the center, the pitch diameter, and the number of teeth for the driving gear when the pitch diameter and the number of teeth for the driven gears are known. It is obvious that an exact solution does not exist for the mentioned task. By means of combined graphical-calculative methods, author finds results which are acceptable with regard to gear meshing. The results are compromises. The analytical determination of the center of the circle which is tangent to three given circles proves to be too lengthy for practical use. Therefore, author applies a trial procedure with the compass.

Reviewer believes that this trial procedure should be substituted by an exact and simple geometrical construction; i.e., by applying the radical center of three circles. The methods presented do not indicate that the results are optimal ones for the given conditions. Minor discrepancies exist in the nomenclature concerning Fig. 7 and the calculations referring to that figure (pp. 15–16).

J. Boehm, USA

Plates, Disks, Shells, Membranes

(See also Revs. 30, 33, 107)

59. Langhaar, H. L., An invariant membrane stress function for shells, *J. appl. Mech.* **20**, 2, 178–182, June 1953.

The equations of equilibrium of membrane stresses in a shell are shown to be satisfied with certain restrictions by a generalized Airy stress function. For shells of constant Gaussian curvature the stress function is shown to be unrestricted. For other shells, it is expressed as a function of the Gaussian curvature. Comparisons are made with Pucher's stress function. Shells of revolution with constant and variable curvature are discussed.

R. L. Bisplinghoff, USA

60. Weber, C., On the effective width of a biaxially corrugated steel plate ("wave steel plate") reinforced by stiffeners (in German), *Bauingenieur* **28**, 3, 5; 81–87, 172–176, Mar., May 1953.

Plate looks like a chessboard; spacing of the straight lines, which are inflection lines for the corrugation, is l. Plate thickness h of this wave steel plate is small compared with l, and theory of thin plates and of shells having a small initial curvature is used. Plate is stiffened in longitudinal direction x at every longitudinal inflection line and in the y-direction by stronger transverse stiffeners at some inflection lines. This stiffened wave steel plate is then supported by longitudinal main girders. Corrugation between inflection lines is of the form $z = f \cos(\pi x/1) \cos(\pi y/1)$,

and looking at such a square, author deduces compatibility equation and gets equation of equilibrium by minimizing total potential energy. Both equations are then expressed in Airy's stress function F and displacement w in the z-direction. Using energy method and approximate expressions for F and w, author calculates stresses and strains in the square for given loads $X \cdot l$ and $Y \cdot l$. It is found that for $h/f = 2/5$ $Xl = 0.54$ $lhE\epsilon_x$, i.e., when wave steel plate and longitudinal stiffeners are uniformly strained as main girders are, 54% of the plate is effective.

Influence of longitudinal stiffeners on $X \cdot l$ and $Y \cdot l$ for given strains ϵ_x and ϵ_y is considered, and shear rigidity of the longitudinally stiffened wave steel plate is calculated by energy method. Using expressions for F and w satisfying compatibility equation and then expressions satisfying equation of equilibrium, author gets upper and lower bounds for shear rigidity. Thus having obtained elastic constants for this orthotropic plate, author shows how to calculate the effective plate width for longitudinal and transverse stiffeners. Method outlined is valid for all orthotropic plates.

E. Steneroth, Sweden

61. Smith, C. B., Some new types of orthotropic plates laminated of orthotropic material, *J. appl. Mech.* **20, 2, 286–288,** June 1953.

The elasticity of composite plates laminated of thin orthotropic plates or plies, identical in thickness and elastic properties, is discussed.

It is shown that, in the case of a two-ply plate, it is possible to use other than a right angle between the principal axes of adjacent plies and still have the composite behave as an orthotropic plate. The axes of elastic symmetry are shown to be the bisectors of the angles between the principal axes of the plies. With some limitations, the analysis can be extended to the general case of a multi-ply plate.

The special cases of plane stress and of a plate bent by a load normal to its faces were discussed for the two-ply plate.

In the case of plywood, the shear modulus of single ply is relatively small, usually being about 6 or 7% of the Young's modulus in the direction of the grain. It is shown that in the case of the laminated plate, the values of the shear modulus increase rapidly as the angle between the grain directions of adjacent plies changes from 0 to 90°.

This analysis should help to provide background for those who are involved in the fabrication and use of laminates.

Y.-H. Pao, USA

62. McComb, H. G., Jr., Stress analysis of sheet-stringer panels with cutouts, *J. aero. Sci.* **20,** 6, 387–401, June 1953.

There is a set of identical stringers, equally spaced and infinite in number. Perpendicular to the stringers is a similar set of rib booms, but these are infinitely stiff against normal forces. Between stringers and rib booms are only shear carrying skin panels. At one intersection of a stringer and a rib boom, an external unit load in stringer direction is applied and the solution for the stress distribution is obtained. The same is done for a unit load distributed along a stringer length between two ribs. Numerical values are given in a set of tables.

By means of these solutions, the perturbation in the stress distribution may be calculated if, in the structure, carrying a certain load, a cutout is made, with reinforcing structural elements in the neighborhood of the cutout. Numerical examples for a structure in uniform tension are given. If there is one cutout in a plate of finite width in rib direction, a solution is obtained by repeated reflection.

If the present analysis could be extended for the case of finite rigidity of the rib booms, this process of reflection would not hold, for then it cannot be guaranteed that the rib forces are zero at the lines of reflection (i.e., the edges of the structure).

J. P. Benthem, Holland

63. Weigand, A., Concerning the analysis of circular cylindrical thick shells under axisymmetrical loading. Application in a problem of a turbogenerator design (in German), *Maschinenbau-Technik* **2,** 4, 144–147, Apr. 1953.

The radial displacement and loading are expanded in Fourier series. The differential equation governing this problem can be found in Biezeno-Grammel, "Technische Dynamik," p. 462. Formulas for the stresses are derived in a normal way. Method is applied to the analysis of the housing of a turbogenerator.

M. Botman, Holland

64. Gedizli, H. S., The circular plate on elastic support under a moment applied to the stiff center piece (in German), *Ing.-Arch.* **21,** 2, 87–89, 1953.

It is assumed that the deflection surface has an equation of the form $w = f(\rho) \cos \vartheta$. This, substituted into the partial-differential equation of the small deflection theory of laterally loaded plates $D\Delta\Delta w - q = 0$, delivers an ordinary differential equation for $f(\rho)$, which is solved. It is then possible to satisfy the necessary displacement boundary condition at the outer edge of the stiff center piece, the usual boundary-equilibrium conditions, and the over-all equilibrium condition.

J. P. Benthem, Holland

65. Mehmel, A., and Fuchssteiner, W., On an approximation method for the analysis of circular cylindrical shells (in German), *Bauingenieur* **28,** 4, 116–123, Apr. 1953

Authors consider a cylindrical roof structure of length $2l$, wall thickness $2h$, radius r, central angle 2ρ, loaded by weight, snow, or wind. Membrane forces, readily determined, are the primary load carriers. However, near the longitudinal edges $X = \pm l$ and lateral ends $\varphi = \pm \rho$ of the roof, the membrane solution violates the prescribed boundary conditions. By considering the roof structure as an array of longitudinal beams on one hand and as an array of transverse arches on the other, resting on elastic foundation, authors determine (in a manner analogous to the usual procedure for determining secondary stresses in trusses) the loads that must be carried by the two central members $\varphi = 0$ and $x = 0$, respectively, so as to re-establish the prescribed boundary conditions in these two positions. It is shown that (to a good approximation) the secondary loads consist only of radial Z loads. The radial deflection w of an arch or a longitudinal beam is associated with a load Z in accordance with the last two terms of the equilibrium equation

$$Z = N_\varphi/r + \partial Q_\varphi/r\partial\varphi + \partial Q_x/\partial x \simeq N_\varphi/r + D\partial^4 w/r^4\partial\varphi^4 + D\partial^4 w/\partial x^4$$

Authors arrive at decaying sinusoidal expressions—of familiar appearance—for bending moment, shear force, etc., in the neighborhoods of the various edges. These secondary solutions are then to be superposed on the membrane solution.

Reviewer calls attention to the many additional recent treatments of the asymmetric-edge loading problem of the cylindrical shell, such as P. Csonka's use of Flügge's equations combined with a stress function [AMR **6**, Rev. 2742], the complex biharmonic function method [W. Zerna, AMR **6**, Rev. 2478], the Donnell equations method [Hoff, Kempner, Pohle, *Quart. appl. Math.*, in press] which likewise provide extensions and simplifications of earlier work by Flügge, Dischinger, Jacobson, etc., and wishes to suggest a comparative appraisal of the various available

methods in regard to their two most important aspects, namely, the length of the calculations (these are sometimes unbearably tedious), and reliability. G. Horvay, USA

66. Goldberg, J. E., Axisymmetric flexural temperature stresses in circular plates, *J. appl. Mech.* **20, 2, 257–260,** June 1953.

A temperature difference (which is a function of the radius only) exists between the top and bottom surfaces of a circular plate. Temperature variation across the thickness of the plate is assumed linear; median plane is kept at constant temperature. Moments and slopes in an infinite plate caused by a constant temperature difference acting on a circular disk are calculated first; subsequently, general expressions are derived by superposition for a finite plate. Worked examples are included showing application to plates with fixed, free, and flexibly built-in edges. G. Sved, Australia

Buckling Problems

67. Dow, N. F., Hickman, W. A., and Rosen, B. W., Effect of variation in rivet strength on the average stress at maximum load for aluminum-alloy, flat, Z-stiffened compression panels that fail by local buckling, *NACA TN* 2963, 17 pp., June 1953.

A study is made of the effect of variation in rivet strength on the average panel stress at maximum load for 75S-T6 aluminum-alloy, flat Z-stiffened compression panels that fail by local buckling. A curve is presented for the determination of the relationship between strength, diameter, and pitch of the rivets, and the strength of stiffened, flat compression panels of such proportions that failure is by local buckling. From authors' summary

68. Hoff, N. J., Nardo, S. V., and Erickson, B., The maximum load supported by an elastic column in a rapid compression test, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 419–423, 1952.

The equation previously derived by Hoff [AMR **4,** Rev. 2434] for the deflection of a pin-ended elastic column in a rapid loading test with constant head speed is further studied. Methods of integration are explained which are suitable for various ranges of deflections and of the dynamic similarity number Ω. Results are given for deflections and forces for Ω ranging from 10^5 to 2.25 (10^6 corresponds to commercial column test; 10 to head velocity 2 in. per sec and slenderness ratio 150). The maximum load is found to be as much as 3 or 4 times the Euler load when the initial deflection ratio and dynamic similarity number are both small. P. S. Symonds, USA

Structures

(See also Revs. 32, 137, 140, 333)

69. Geisslreiter, A., Moment superposition in multiple-story frames (in German), *Beton u. Stahlbetonbau* **48,** 6, 136–140, June 1953.

Author refers to Lamberg's paper published in title source, 1950, and derives simplified graphical presentation of moment distribution in any multiple-story frame under the most unfavorable loading of surrounding spans. Lamberg's method is based on analytical principles originated by C. V. Klouček [see: *Zpr. ver. s. techn.*, no. 18, 1939; "Das Prinzip der fortgeleiteten Verformung," Berlin, 1941; also AMR **4,** Rev. 4143]. Author's loading diagrams to be used for any number of stories and spans considerably simplify the otherwise intricate analysis. Diagrams refer to two loading schemes: (1) Within an accuracy of approximately 1%; (2) giving still greater accuracy which, however, is not necessary for practical structural problems.

J. J. Polivka, USA

70. Roubakine, G., Extension of the influence line method to the calculation of pin-jointed trusses in space (in French), *Bull. tech. Suisse Rom.* **79,** 11–12, 259–266, June 1953.

With Mayor's method it is possible to transform problems of concurrent forces or bars in space into plane ones. After reviewing particularities of this method, the author applies it to the determination of a discontinuous field of vectors in space, which gives the influences of pin forces on the force in a bar of a pin-jointed truss in space.

A numerical example is developed and a complete bibliography on Mayor's method is added. A. J. Bignoli, Argentina

71. Francis, A. J., Some recent developments in structural analysis and design, Instn. Engrs., Australia; Proc. Engng. Conf., 1953, pp. 1–11.

Paper reviews in a somewhat sketchy form developments during the past 20 years in elastic-truss and frame analysis, analysis of shells and cellular structures, plastic analysis of mild-steel structural connections and frames, as well as of reinforced-concrete beams; it closes with a short discussion of the concept of safety. Neither discussion nor bibliography is comprehensive.

A. M. Freudenthal, USA

72. Francis, A. J., Direct design of elastic statically indeterminate triangulated frameworks for single systems of loads, *Austral. J. appl. Sci.* **4,** 2, 175–185, June 1953.

Paper describes a method of design of elastic statically indeterminate triangulated frameworks for a single system of loads. The classical indirect approach based on indeterminate structural theory is replaced by a direct approach which yields an economical solution in a very short time. The general principle of prestressing follows naturally from the method and is shown to lead to appreciable economy in material in two simple illustrative problems. From author's summary

73. Sattler, K., Theory of composite structures [Theorie der Verbundkonstruktionen], Berlin, Wilhelm Ernst & Sohn, 1953, xii + 300 pp. DM 43.

This book is intended for civil engineers working in the design of composite structures, mainly—composite beams with shear connectors. In the first part, author develops the theory of the combined statical action of composite beams under the influence of the variable modulus of elasticity, prestressing, plastic deformation (creep of concrete), shrinkage, and temperature changes. In the second part are given the numerous examples of application of this theory to the design of different composite structures, such as floors of buildings and bridges, columns, arches, and other forms of statically determinate and indeterminate structures.

Reviewer thinks that this book fills a gap in the design of reinforced-concrete structures and recommends it for practicing engineers. J. B. Gabrys, USA

74. Heilig, R., Theory of elastic connections (for composite construction) (in German), *Stahlbau* **22,** 5, 104–108, May 1953.

Usual assumptions of elasticity and assumption of a modulus of connection are made. Using equilibrium equations and displacement moment and direct stress equations, three differential equations involving three displacement functions are derived in dimensionless terms. By elimination, a homogeneous differential equation of the 6th order is obtained for the deflection. The solu-

tions of the three differential equations for displacements contain eight constants of integration to be determined by use of boundary conditions. For a simple composite beam, say of concrete and steel, with a concentrated load, sixteen boundary conditions are given and expressions developed for unit stress in concrete and steel. Expressions to include effect of temperature variation are developed. Reviewer believes unit stress expressions would be helpful in evaluating composite design (buildings and bridges) when members consist of concrete and rolled steel sections. Modulus of connection is considered constant over span. Modulus is quite difficult to evaluate. R. B. B. Moorman, USA

75. **Villard, A., Investigations on reduced models of reinforced-concrete structures** (in French), *Bull. tech. Suisse Rom.* 79, 11–12, 266–271, June 1953.

Article discusses tests of small models of three reinforced-concrete structures, two of which are skewed bridge slabs and the other a shell roof. The bridge-slab models were constructed of pumice concrete, one to a scale of 1:20 and the other to a scale of 1:16.5. Moment diagrams and influence lines are included for one of the bridge slabs. The shell-roof model was constructed of celluloid to a scale of 1:25. J. P. Michalos, USA

76. **Jäger, K., A procedure for the design of continuous beams of reinforced concrete, taking into account the properties of the materials (translated by J. C. Van Tienhoven),** *Wwys. Exp. Sta. Transl.* no. 53–54, 27 pp., June 1953.

This paper deals with a more accurate determination of the bending moments in statically indeterminate reinforced-concrete beams, taking into account the variable bending stiffness resulting from the distribution of the steel reinforcements, which bending stiffness is defined by the support moment sustainable in each cross section. From author's summary

77. **Rinaldi, G., Fracture analysis of reinforced-concrete structures. New regulations in Czechoslovakia** (in Italian), *G. Gen. civ.* **91,** 4, 191–193, Apr. 1953.

78. **Peebles, J. J., The equivalent rectangle in prestressed concrete design,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 187, 11 pp., Apr. 1953.

Author presents a method whereby necessary dimensions of regular and irregular cross sections of prestressed-concrete beams can be determined by comparing the actual sectional shape with a rectangular cross section. By means of coefficients to compensate for the difference in shape, the necessary dimensions can be taken from a chart after a few trial computations. Examples are given. C. J. Bernhardt, Norway

79. **Paoli, R., Measurement of the surface characteristics of highways** (in Spanish), *Inform. Construc.* **5,** no. 50, 8 pp., Apr. 1953.

Description of an instrument for the measurement of surface characteristics of highways. Mechanism is designed so as to permit simple classification of highway pavements and to detect even small irregularities and deficiencies.

From author's summary by M. A. Dengler, USA

80. **Salvadori, M. G., Earthquake stresses in shear buildings,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 177, 23 pp., Mar. 1953.

Assuming the mass of the building is lumped at the floor levels and the motion is due to the bending deflections of the columns only, the horizontal shearing motion of the building is treated. The rocking motion is also treated briefly. Some numerical examples which give the modes and frequencies are given, but it seems to the reviewer that they are used rather to explain the methods of solving the problem than to discuss the earthquake stresses. T. Mogami, Japan

81. **Fiesinger, H., Design, calculation, and construction of Diesel engine foundations under dynamic stresses, using reinforced concrete with admixtures of brick fragments** (in German), *Bautechnik* **30,** 5, 121–127, May 1953.

Foundation design of test stand for heavy, low-speed, diesel engines which does not transmit vibration to surrounding areas. Author, who is connected with Degebo (German Society for Soil Mechanics), uses vibration equipment developed by this organization to measure vertical and horizontal vibration constants of soil. Design of foundation block proceeds according to the methods of Rausch in such a way that the natural frequency of machine and foundation is considerably above the low engine frequency. Reviewer believes that while this method is based on the somewhat unrealistic assumption of a soil acting as a linear spring, it is superior to those generally applied in the United States. Numerical calculations are given in detail, as are most constructional features. E. G. Chilton, USA

82. **Ohde, J., Simplified calculation of dam bases for bending resistance** (in German), *Bautechnik* **30,** 5, 140–146, May 1953.

This study concerns a new method for the calculation of the walls and dam bases in sluices and basins. Besides the weight of the masonry, the water pressure likely to act in both directions, and the earth thrust, the method takes into account the part played by the deformation of the foundation soil. The method gains its originality through its inclusion of the last-mentioned mechanism. The formulas can be immediately used and one example facilitates their application. L. Escande, France

83. **Link, H., New water reservoirs and dams in Austria** (in German), *Bautechnik* **30,** 2, 42–50, Feb. 1953.

THE FOLLOWING PAPERS (REVS. 84–89) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, 4 vols. $48 per set.

84. **Duquennois, H., Statistical research on solid sediments and their draining off by underflow** (in French), vol. IV, 119–135.

85. **Drouhin, Mallet, and Pacquant, The sedimentation of storage basins in Algeria** (in French), vol. IV, 163–195.

86. **Remenieras, G., and Braudeau, G., Some observations on sedimentation in French reservoirs** (in French), vol. IV, 197–236.

Chapter I reviews the factors determining the deposit of silt and the manner of sediment formation in reservoirs. The development of the typography of earth deposits, formed by drifted material on the bottom, is studied in some detail in the case of a prismatic impounding reservoir and in the case of actual reservoirs, taking into consideration the variation of the solid and liquid discharges and the reservoir level. Some indications are subsequently given on the deposit of materials held in suspension and the resulting stream densities produced under certain particular conditions.

Chap. II analyzes the observations made on the Motty and Sautet reservoirs, which are located on the Drac River. The

characteristics (orography, geology, hypsometry, rate of flow) of the watershed, common for these two reservoirs, are discussed briefly.

Chapter III summarizes the observations made on the Petite Rhue reservoir (total capacity: 400,000 cubic meters–14,120,000 cubic feet) in the Massif Central. From 1927 to 1938 the deposits reached 60,000 cubic meters–2,118,000 cubic feet—of which 18,000 cubic meters–635,400 cubic feet were vegetable debris.

Chap. IV groups some information on the silt deposits in several reservoirs in the Alps (Vallières, Jonage), in the Pyrénées (Anglus, Le Peilhou, Gèdre), and in the Massif Central (Pinet).

From authors' summary

87. **Marcello, C., Santa Giustina Dam,** vol. IV, 485–499.

Brief description of the Santa Giustina dam, the highest to date in Europe and, among arch dams, the second highest in the whole world after the Ross dam (United States). The main geometric data of the structure are given and the methods followed in the stability analysis are described.

Particularly interesting is the exceptional strength of the concrete, proportions and mixing of which have been carefully studied and controlled. Another interesting feature of this structure is the system adopted to insure perfect watertightness of the abutments, the rock of which was very unsatisfactory from this point of view. From author's summary

88. **Lyubchenko, B. M., Theory and practice of standard engineering normalization for dam design and construction in the U.S.S.R.,** vol. IV, 525–556.

This paper points out that the tremendous scale of construction in the USSR demanded an extensive development of standard engineering normalization of construction planning and methods on the basis of the achievements of advanced Soviet science and building technique. As a result of this, standard engineering normalization in the field of civil engineering has acquired state importance.

The paper further points out that standard engineering normalization in dam designing and construction is based on scientific conceptions of the work of structures and their foundations, and this allows for the normalization of calculations of structures and their elements, adoption of safety factors, calculation of foundations, requirements for soil investigations, etc., to be approached scientifically.

The report also contains the basic principles, peculiarities, and brief contents of the most important normalizing codes and specifications for designing stages, classification by importance, calculation and designing, engineering hydraulics, construction methods for hydraulic structures, investigations, and surveying.

From author's summary

89. **Mikhailov, V. N., New method of reinforcing hydraulic structures,** vol. IV, 557–629.

The idea of utilizing preassembled reinforcing steel constructions originated in 1936 during the construction of the Moscow-Volga Canal. This involved the manufacture and assembly of reinforcing constructions away from the construction site, thus providing for a speeding-up of the construction of large-scale hydraulic structures, the reinforcing operations period being 6 to 7 times less as compared with the method of mounting separate rods in concrete blocks.

This new method is at present finding wide practical application in large-scale hydraulic and industrial constructions in the USSR.

This report deals with the advantages and peculiarities of designing, constructing, and erecting hydraulic structures with the utilization of reinforcing constructions.

From author's summary

90. **McGuigan, M. J., Jr., Interim report on a fatigue investigation of a full-scale transport aircraft wing structure,** *NACA TN* 2920, 36 pp., May 1953.

Results are presented of an investigation of the fatigue strength of several full-scale aircraft wing structures. The test specimens were obtained from C-46 Commando-type airplanes and the tests described are the first phase of a larger research program on the fatigue strength of full-scale aircraft. The tests were conducted by the resonant-frequency method at a level of 1 ± 0.625 g or about $22 \pm 14\%$ of the design ultimate load factor.

The 34 fatigue failures which resulted from these tests were of four main types and occurred in three principal localities on the test wings. The average lifetime for these tests was about 200,000 cycles. The over-all spread for all failures was 4.4 to 1.0 and, for similar failures repeatedly occurring in the same localities, it was as low as 1.2 to 1.0. Effective stress-concentration factors were calculated for all failures and indicated a value of about 4.0 for an inspection cutout and 2.3 for a riveted tension joint.

During the tests no change was noted in either the natural frequency or damping characteristics of the test specimens prior to the development of a fatigue crack. When a crack did occur, its rate of growth was rather slow until about 5 to 9% of the tension material had failed, after which the rate of crack growth increased rapidly.

From author's summary by G. Gerard, USA

91. **Peters, R. W., and Stein, M., Deflection of delta wings having a carry-through-bay chord smaller than the wing root chord,** *NACA TN* 2927, 25 pp., May 1953.

The theoretical tip-load deflection for a constant-thickness delta wing (elastically supported by a carry-through bay 35% of the wing-root chord in width) is calculated by the method presented in *NACA TN* 2621 [AMR **5**, Rev. 2816]. The tip deflection doubles as a result of this removal of 65% of the root chord. Experimental deflections at the tip are found to exceed those computed by approximately 20%. G. E. Nitzberg, USA

92. **Keen, E. D., Integral construction, its application to aircraft design and its effect on production methods,** *J. roy. aero. Soc.* **57**, 508, 215–227, Apr. 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 90, 123, 153)

93. **Kittel, C., Introduction to solid state physics,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, xiii + 396 pp. $7.

Author states that "the volume is intended as an introductory textbook in solid-state physics for senior and beginning graduate students in physics, chemistry, and engineering. . . supposes that the reader will have a general familiarity with modern atomic physics." Emphasis is on theoretical models of solids, little attention being paid to experimental methods, but with results of many researches shown in graphical form. About 600 papers from about 400 authors are cited. Although space limitations prevented the inclusion of certain interesting fields, there is still an enormous amount of information collected here. The first paragraph of almost every chapter is devoted to a summary of the material to be covered in that chapter. A brief list of problems and additional references are added to each chapter.

Reviewer feels that lack of adequate descriptive material is a limitation. The author apparently includes this material as visual aids in classroom presentations, but it is missing from the book with a resultant lack of completeness in many places. Topics covered include classification rules; lattice energies; lattice vibrations; thermal, electric, and magnetic properties; super- and semi-conductors; free electron and band theory of metals; solid imperfections. T. A. Hunter, USA

94. **Thompson, N., Dislocation nodes in face-centred cubic lattices,** *Proc. phys. Soc. Lond.* (*B*) **66,** part 6, 402B, 481–492, June 1953.

Burgers vectors (defined in appendix) are used to describe various dislocations of an FCC lattice. Both twofold and threefold nodes are treated, and 37 possibilities are described. Operation of a dislocation which rotates in its glide plane (Frank-Read source) is considered in detail, showing that the most firmly anchored nodes may move progressively. Treatment is strictly three-dimensional. T. A. Hunter, USA

95. **Geiringer, Hilda, Some recent results in the theory of an ideal plastic body,** Advances in appl. Mech. III, 197–294, 1953. $9. [Academic Press, Inc., N. Y.]

An expository article summarizing recent work of the author and others in the analysis of two-dimensional plastic-rigid analysis. Three main sections are entitled "Definition and derivation of a general plane problem," "On the general plane problem," and "Examples of complete problems." In part I, two-dimensional problems corresponding to plane strain and plane stress are derived from three-dimensional problem with arbitrary isotropic yield condition. The function used as plastic potential in stress-strain law may or may not be the same as the yield function. Author does not mention recent work of Drucker advancing thermodynamic reasons why these two functions should coincide, but such coincidence is assumed in most of the article. Part II deals with various methods of attacking general plane problem. Most of this section is summarized from author's previous papers, but at least one result proving that a plastic-rigid boundary must be a characteristic appears to be new. Author fails to point out that in plane stress problem even the general approach used may be inadequate because plastic flow out of the plane may be fundamental. Part III is based primarily on Lee's work in complete plane strain solutions. While article as a whole is not easy to read, it contains a wealth of information for those interested in a mathematical approach to two-dimensional plasticity problems. List of references contains 58 items by 23 writers (including 7 by author) which contain source material for article.

P. G. Hodge, Jr., USA

96. **Shield, R. T., and Drucker, D. C., The application of limit analysis to punch-indentation problems,** Nat. Conf. appl. Mech., Minneapolis, June 1953. ASME Paper no. 53—APM-21, 8 pp.

Limit analysis is applied to obtain upper and lower bounds for the punch pressure in the indentation of the plane surface of an elastic perfectly plastic material by a flat rigid punch. The two-dimensional flat punch and the three-dimensional flat square and rectangular punch problems are considered. The analysis assumes Tresca's yield criterion of constant maximum shearing stress k during plastic deformation. It is shown that the pressure required to produce indentation in the two-dimensional problem lies between $5k$ and $(2 + \pi)k$. The lower bound obtained for any rectangular punch is again $5k$, while the upper bound for a smooth punch lies between $5.71k$ for a square and $(2 + \pi)k$ for a very long rectangle. A value of $5.36k$ is found for a ratio of length to breadth of 3. The limit pressure for a uniformly loaded area, as distinguished from an area loaded by a punch, is bracketed by $5k$ and $(2 + \pi)k$ when the area is convex.

From authors' summary by F. R. N. Nabarro, England

97. **Weinberg, E. H., The creep of zinc single crystals under direct shear,** *J. appl. Phys.* **24,** 6, 734–744, June 1953.

Room temperature measurements on very pure specimens verify the Tyndall law, $s = at^m$, which was determined by tensile measurements. The value of m is approximately 0.6. Discrepancies in tensile creep tests reported by other observers are shown experimentally to be caused most probably by bending of the specimen during the creep process. The Bauschinger effect has also been investigated, and creep at the very small stresses needed appears to follow the same creep law.

From author's summary by R. Hill, England

98. **Hikage, T., On the microhardness of aluminium single crystal,** *Sci. Rep. Res. Inst. Tohôku Univ. Japan* (*A*) **5,** 3, 254–262, June 1953.

Paper describes microhardness tester in which the applied load is only 8 grams. Hardness measurements were made at spacings of 0.3 mm on several single crystals of aluminum. The microhardness of an annealed crystal showed large fluctuations indicating a considerable inhomogeneity. Hardness reading taken on regions of the crystal intervening between primary slip lines indicated fairly large amounts of strain hardening in the presumably undeformed material. At the initiation of double slip there is a temporary drop in the mean of the microhardness readings.

E. A. Davis, USA

99. **Bestul, A. B., and Belcher, H. V., Temperature coefficients of non-Newtonian viscosity at fixed shearing stress and at fixed rate of shear,** *J. appl. Phys.* **24,** 6, 696–702, June 1953.

Andrade's formula for viscosity, modified by Eyring, has been the subject of several investigations and this paper is another attempt at finding the validity of the latter's hypothesis. The authors have carried out experiments to determine the effect, on variation of viscosity with temperature, of two parameters, namely, shear stress and rate of shear. They have found that the variation is more at a fixed shear stress than at fixed rate of shear. They have also artificially separated the effects of stress and rate of shear and analytically supported their experiments. Perhaps this sort of treatment oversimplifies the picture.

"Structural viscosity" or "viscosity" in substances like rubber have a defined meaning, which loses significance at higher stresses due to the breakdown in the linkages with increasing stress. This phenomenon is also connected with the decrease in viscosity with increase in stress, which has been verified by the authors, and an interpolation formula has been suggested, of the form: $1/\eta = a + bs^2$, where η is the viscosity, s the stress, and a and b are constants. The conclusion that the variation of viscosity with temperature decreases with higher rates of shear, which can be drawn by a superficial examination of Fig. 1, has to be treated cautiously, as that region is associated with a higher stress, where the word "viscosity" may lose its meaning.

In the regions of lower shear stress, for which the Eyring formula may be adequate, the experiments support it, at least qualitatively. Y. V. G. Acharya, Holland

100. **Kennedy, A. J., On the generality of the cubic creep function,** *J. Mech. Phys. Solids* **1,** 3, 172–181, Apr. 1953.

Andrade's equation for creep consists of two terms, one interpreted as a transient flow proportional to $(\text{time})^{1/3}$, and the other a permanent flow which is exponential in time. The cube-root

law is obeyed approximately by a wide variety of substances, including metals, plastics, rubbers, and concrete. Author proposes that this is the basic creep law of any aggregate in which each unit contributes a finite strain in changing from a weak state to a strong one.

A model consisting of studs resting on a viscous surface and interconnected by both a taut network of weak threads and a slack network of strong threads was found to follow a cube-root law, which lends plausibility to the proposal. The author is currently endeavoring to put these ideas on a firmer basis as applied to metals, apparently primarily by studying the statistics of model aggregates. Reviewer believes the work could profit by a complementary study of the physical basis of creep.

S. B. Batdorf, USA

101. Manson, S. S., and Haferd, A. M., A linear time-temperature relation for extrapolation of creep and stress-rupture data, *NACA TN* 2890, 49 pp., Mar. 1953.

This is a very valuable paper in which the authors examine the data on high-temperature creep and creep-fracture tests on ferritic and austenitic steels, high temperature resisting alloys, and aluminum alloys. The study covers 40 materials. They found that, when the logarithm of the rupture time t is plotted directly against the temperature T with the nominal stress σ as a parameter held constant, reasonably straight lines result, converging in a single point T_a, $\log t_a$. Based on their careful examinations, a formula $(T - T_a)/\log (t/t_a) = \text{const}$ is proposed for the extrapolation of creep-rupture tests under a constant stress at elevated temperatures. In order to correlate total creep strain rate tests they propose the formula $(T - T_a)/\log (r/r_a) = \text{const}$, where r is the minimum creep rate and T_a, t_a, r_a are material constants. When $\log t$ was plotted against the reciprocal of the absolute temperature $\Theta = T + 460$ (a relation that has been proposed in the literature), systematic deviations were observed from the formula. The paper is illustrated by 15 carefully discussed curve sheets representing test results.

A. Nadai, USA

102. Mott, N. F., A theory of work-hardening of metals. II: Flow without slip-lines, recovery and creep, *Phil. Mag.* (7) **44,** 354, 742–765, July 1953.

Author's previous theory of work-hardening is extended to account for fine slip. It is suggested that fine slip and coarse slip both have their origin in Frank-Read sources, but that fine slip occurs when the dislocations move slowly. This occurs when the stress Gb/l required to obtain dislocations from a source is less than the stress required to drive them through the obstacles in the lattice without the help of thermal activation. The initial stages of deformation are normally by fine slip, and the hardening in this region is shown to be much slower than for coarse slip. In creep, the deformation is normally by fine slip; a discussion is given on this basis of logarithmic creep, which agrees better with experiment than previous exhaustion theories. A new theory is given of Andrade's β-creep, which relates it closely to steady-state creep. Finally, a discussion is given of the formation of vacancies during creep. From author's summary by J. C. Fisher, USA

103. Green, A. P., The plastic yielding of notched bars due to bending, *Quart. J. Mech. appl. Math.* **6,** part 2, 223–239, June 1953.

Extremum principles are applied to the problem of estimating loads sufficient to cause pronounced plastic yielding in notched bars. The theory is two-dimensional and an ideal plastic-rigid material is assumed. Upper bounds to the constraint factors in pure bending are obtained for deep notches with circular and wedge-shaped roots and for shallow notches of any shape. The estimates for deep notches are calculated by means of slip-line fields constructed to satisfy all conditions in the plastic region; but since the associated stress distributions in the rigid zones are not examined, it is not known theoretically whether these are complete solutions. A simple method is presented for ascertaining whether the rate of plastic work is positive in a given slip-line field.

Experiments are described in which wide bars of copper, stainless steel, and mild steel, deeply notched on one side only with a single wedge-shaped notch, were bent by pure couples applied at each end. The yield-point couples, the surface deformation, and the regions of plastic deformation (revealed by etching bent mild-steel specimens) agreed closely with the theory.

From author's summary by T. H. Lin, USA

104. Hill, R., and Siebel, M. P. L., On the plastic distortion of solid bars by combined bending and twisting, *J. Mech. Phys. Solids* **1,** 3, 207–214, Apr. 1953.

Using the inequalities of limit analysis, authors derive an interaction formula for combined tension, bending, and twisting of a solid bar of constant cross section. When the ratios between axial force and bending and twisting moments are prescribed, this formula gives the asymptotic values of these quantities, but no information regarding the rapidity with which these asymptotic values are approached as the deformations increase. To obtain this information, authors subjected bars of solid circular section to combined bending and twisting. The ratio between bending and twisting moments was kept constant during each test. It was found that the bending and twisting moments practically attain the asymptotic values when the strains equal from 2 to 2.5 times the strains at the elastic limit. W. Prager, USA

105. Thomas, T. Y., On the inclination of plastic slip bands in flat bars in tension tests, *Proc. nat. Acad. Sci. Wash.* **39,** 4, 257–265, Apr. 1953.

Author maintains that the accepted theory of oblique necking of a thin tension strip, as given for instance in Nadai's book, is not rigorous in that, instead of the conditions of equilibrium being satisfied by the stresses acting on either side of the bounding surfaces of the neck, the assumption is introduced that the strain component along the neck is zero. Reviewer notes, however, that this assumption is also implicit in Eq. (11) of author's alternative derivation of the same final results, and further that, contrary to author's belief, in Nadai's derivation the stress state in the neck is taken as *identical* with that in the remainder of the strip. In effect, author merely introduces this same fact in a roundabout way by making the stress state in the neck satisfy two continuity conditions and a yield criterion. Author's conception of necking is unusual, since he equates the plastic through-thickness strain in the neck with the corresponding elastic strain outside. R. Hill, England

106. Thomas, T. Y., The effect of compressibility on the inclination of plastic slip bands in flat bars, *Proc. nat. Acad. Sci. Wash.* **39,** 4, 266–273, Apr. 1953.

Same theory as in previous review, with compressibility introduced by way of Hencky plastic stress-strain relations.

R. Hill, England

107. Siebel, M. P. L., The combined bending and twisting of thin cylinders in the plastic range, *J. Mech. Phys. Solids* **1,** 3, 189–206, Apr. 1953.

The typical stress-strain law of the theory of perfectly plastic solids is based on the assumption that the relation between the

stress, stress rate, and strain rate of a given particle is not affected by the stresses, stress rates, and strain rates of adjacent particles. After experiments have established the validity of a proposed stress-strain law for homogeneous stress and strain, the validity of this assumption remains to be checked experimentally. For this purpose the present author used combined bending and twisting of thin-walled circular tubes made of a special steel (E steel) with a stress-strain curve closely approximating that of a perfectly plastic solid. The ratio between bending and twisting moments was kept constant during each test, and extension, angle of twist, and warping were measured. The results were found to be in excellent agreement with the formulas that Hill and Siebel [AMR **5**, Rev. 1351] derived on the basis of the stress-strain law of Prandtl and Reuss. W. Prager, USA

108. **Schultz-Grunow, F., and Weymann, H., New methods for the measurement of flow curves and relaxation times with capillary and rotational viscometers and discussion of the Prandtl theory in the light of experimental investigations** (in German), *Kolloid Z.* **131**, 2, 61–66, May 1953.

Authors discuss determination of flow curves of non-Newtonian fluids from capillary and rotational viscometer data. A new capillary viscometer is described in which the pressure gradient is measured from the expansion of the capillary tube, employing strain gages. Rotational viscometer data on a polystyrene solution in toluene and on a butyl acrylate polyester at various temperatures are interpreted, using Prandtl and Vandrey's [AMR **4**, Rev. 668] flow equation. A method is derived for the determination of the relaxation time of a Maxwell fluid using a capillary viscometer. I. M. Krieger, USA

109. **Johnston, B. G., Yang, C. H., and Beedle, L. S., An evaluation of plastic analysis as applied to structural design,** Repr. from *Weld. J. Res. Supp.*, 16 pp., May 1953.

Failure, Mechanics of Solid State

(See also Revs. 50, 77, 102, 130, 139, 143, 144, 367)

110. **Robertson, T. S., and Hunt, D. le M., The propagation of brittle fracture,** Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 456, 17 pp., May 1953.

In investigating the propagation of cracks in ship-plate steel at subnormal temperatures, authors use unique testing method to produce a determinate force system. Results provide critical relation between temperature and stress required to propagate a crack. An interesting effect observed by the authors is that the force for propagation at a given temperature and for a given material is constant whatever the length of crack. Authors also conclude that plastic yielding takes place only at the tip end of the crack after propagation has stopped, which, reviewer believes, may not be a completely valid conclusion.

A. D. Schwope, USA

111. **Coffin, L. F., Jr., A study of the effects of cyclic thermal stresses on a ductile metal,** *Knolls Atomic Power Lab. Rep. KAPL-853*, 129 pp., June 1953.

The results of a study of cyclic strain and fatigue failure arising from cyclic thermal stresses are reported. By means of a test apparatus described in a companion report [Coffin, L. F., Jr., and Wesley, R. P., "An apparatus for the study of the effects of cyclic thermal stresses on ductile metals," *KAPL-830*, Oct. 27, 1952], a cyclic temperature is imposed on a thin tubular test specimen subjected to complete longitudinal constraint. Hence, the cyclic strain is the independent variable.

The following studies are reported: (1) Effect of thermal stress cycling on strain hardening and life-to-failure for a fixed mean temperature; (2) effect of degree and kind of previous cold work on strain hardening and cycles-to-failure; (3) effect of mean temperature on thermal stress cycling; (4) effect of period of cycle on cycles-to-failure; (5) effect of prior strain cycling on stress-strain characteristics; and (6) effect of stress concentrations on fatigue by cyclic thermal stresses.

The significance of factors such as hysteresis, Bauschinger effect, strain hardening, strain aging, and fatigue-crack formation are discussed, and a mechanism is described to relate these factors. Evidence is presented to show that strain hardening is not an important factor in the problem. The concept of total plastic strain is discussed. From author's summary

112. **MacKenzie, I. M., Notch ductility of mild steel ship quality plates,** Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 455, 35 pp., May 1953.

Brittle failures of mild steel appear to have become more common recently because of the progressive increase in the thickness of the plates used. A statistical investigation was made to correlate notch ductility with chemical composition, plate thickness, and rolling procedure. Increased finishing temperature and a higher phosphorus content reduced the notch ductility, whereas increases in the manganese and nickel contents improved it. The thicker plates were more brittle because of the higher finishing temperatures used and their slower rates of cooling. This influenced the structure adversely, because slow cooling through the transformation range produced a coarser ferritic structure. The author considers that the most promising methods of improving notch ductility are increasing the manganese:carbon ratio, normalizing and deoxidizing with aluminum.

A. F. C. Brown, England

Material Test Techniques

(See also Revs. 68, 124, 137, 143)

113. **Cottrell, C. L. M., Controlled thermal severity cracking test simulates practical welded joints,** *Weld. J.* **32**, 6, 257–272, June 1953.

Paper describes an investigation to develop a simple test for determining cracking propensity in the hardened zone of the plate immediately adjacent to the fusion line in arc-welded low-alloy steel. Various test welds were studied and compared with welded structural joints, rate of cooling in the hard zone being used as a basis for comparison. Results indicated a relationship, when using a given steel and electrode, between rate of cooling at 300 C in the hard zone and incidence of hard-zone cracking.

A weldability test was devised which provides known grades of thermal severity (cooling rates) covering the range obtained in structural joints. This new CTS (Controlled Thermal Severity) test was used to derive an empirical equation which relates rate of cooling in the hard zone to fillet size (single pass) and geometry of the welded joint. A weldability index is proposed, based on the CTS test, for classifying low-alloy steels according to their liability to hard-zone cracking, taking into account the type of electrode used. From author's summary by F. J. Winsor, USA

114. **Wesche, K., Concrete testing with ultrasonics** (in German), *Beton u. Stahlbetonbau* **48**, 5, 116–119, May 1953.

Paper is a fairly complete and well set-out review of nearly all the developments in which the time of transmission or velocity of

ultrasonic waves or pulses in concrete is used as a measure of the quality of the concrete. Both transverse and longitudinal waves are discussed. Article is probably of more interest to European readers than others. F. A. Blakey, Australia

115. **Bergstrom, S. G., Laboratory tests on vibration of concrete,** *J. Amer. Concr. Inst.* **24,** 10, 893–908, June 1953.

116. **Iwayanagi, S., and Hideshima, T., Low frequency coupled oscillator and its application to high polymer study,** *J. phys. Soc. Japan* **8,** 3, 365–371, May-June 1953.

Authors describe a coupled pendulum method of measuring dynamic elastic constants at low frequencies. The original method is due to Le Rolland [*C. R. Acad. Sci.* **192,** 336, 1931; **227,** 37, 1948] and Kovacs [ibid., **227,** 1019, 1948], and the reviewer has had practical experience as to its simplicity. The method has been applied to measurements of dynamic torsional constants over temperature range −20 C to +150 C, and energy absorption maxima were found at temperatures about 20 C and 130 C, the upper temperature maxima corresponding to the change to rubberlike elasticity. A second part describes further experiments to study the lower temperature maxima. More conventional transducers were used to measure dynamic constants in vibration and torsion, and detailed study of the secondary absorption region in polymethyl methacrylate was made. Results give activation energy of 29 K cal/mol for absorption mechanism, and authors briefly discuss molecular theory in conjunction with electrical results of Mead and Fuoss [*J. Amer. chem. Soc.* **64,** p. 2389, 1942]. K. W. Hillier, England

117. **Phelps, G. W., Woodward, J. G., and Maguire, S. G., Testing with the vibrating-plate viscometer,** *J. Amer. ceram. Soc.* **36,** 2, 60–65, Feb. 1953.

A series of art-ware and sanitary-ware slips was tested using the vibrating-plate viscometer. Results obtained with this instrument are in the form of "casting curves" that depict slip consistency as a function of time during the casting operation. Various features of the casting curves are compared with data obtained by more conventional test procedures. Correlations are found between casting-curve parameters and such factors as initial slip fluidity, casting rate, retained water, and quality of finished cast. The physical significance of certain aspects of the casting curves is discussed. From authors' summary

118. **Woolf, D. O., Improvement in the uniformity of the accelerated soundness test of coarse aggregate,** *ASTM Bull.* no. 187, 42–46, Jan. 1953.

The development of the present standard gradings used in the accelerated soundness test for coarse aggregates is described, with an explanation for the lack of agreement among different laboratories in check tests of the same aggregate. To correct this difficulty, the testing of aggregates in single sizes and the use of the "half-size" sieve for the determination of the loss are recommended. With the use of this method, losses of 6 to 9% may be substituted for losses of 10 to 15% as determined by the present method of test in which combinations of individual sizes of coarse aggregates are involved. The immediate revision of specification requirements for coarse aggregate is recommended to insure that material of a known quality will be obtained.

From author's summary

119. **Macinante, J. A., and Peres, N. J. C., Diamond pyramidal hardness testing of spherical specimens,** *Commonwealth sci. industr. Res. Org., Australia, Tech. Pap.* no. 1. 9 pp., 1953.

Exact and approximate expressions are derived for the area of a pyramidal indentation in a spherical specimen, and a simple technique is given for making a diamond pyramidal hardness test on a small steel ball (diam. 1 mm). From authors' summary

Mechanical Properties of Specific Materials

(See also Revs. 67, 71, 93, 110, 112, 114, 116)

120. **Dienes, G. J., Effects of nuclear radiations on the mechanical properties of solids,** *J. appl. Phys.* **24,** 6, 666–674, June 1953.

The purpose of the paper is to focus attention on mechanical properties of materials and to discuss the effects of radiation on them. Current theoretical understanding of mechanical properties of solids is critically evaluated. It is shown that changes in mechanical properties of crystalline substances can be satisfactorily interpreted on the basis of production of interstitial atoms and vacant lattice sites by fast particle irradiation. Mechanical properties of the materials can be discussed, according to author, at two levels; the phenomenological, and the atomic or molecular level. The former deals with a group of phenomena which can be quantitatively correlated and described, while the latter goes considerably further and requires that a group of phenomena be describable and predictable from known atomic characteristics. Author suggests experiments which should give further insight into the fundamental process involved.

S. K. Ghaswala, India

121. **Cochardt, A. W., The origin of damping in high-strength ferromagnetic alloys,** *J. appl. Mech.* **20,** 2, 196–200, June 1953.

The mechanical damping of standard high-strength alloys under engineering stresses is caused mainly by magnetostriction, although plastic flow predominates as a damping mechanism under excessively large stresses and many effects contribute when the stresses are small. This is confirmed by the great reduction of damping on testing in a strong magnetic field.

Up to a critical stress σ_c, the energy loss per cycle is proportional to the cube of the applied stress. Above σ_c, the loss per cycle is constant. Because of this nonlinearity, the relation of logarithmic damping to stress amplitude is different for torsional and for flexural vibrations. These relations are calculated and experimentally confirmed with reasonable accuracy, using the known value of the magnetostriction and choosing σ_c to fit the experimental curve. Both 12% chrome steel and Co-30% Fe alloys were used. F. R. N. Nabarro, South Africa

122. **Szabó, Ö., Influence of the microstructure of plain carbon steels on their deformation characteristics** (in German), *Acta Techn. Hung.* **6,** 3–4, 351–386, 1953.

The distribution of elongation and reduction of cross-sectional area in tensile specimens of mild steel is determined from photographs of specimens 10 mm in diameter provided with transverse marks 5 mm apart. The measurements show that lateral contraction continues outside the necked-down portion even after the maximum load has been reached and necking has started. On the basis of these measurements, the author proposes $\tan \gamma = (\sigma_C - \sigma_F)/\psi$ as an index of strain-hardening where σ_M is the stress at rupture based on the minimum section, at the bottom of the neck, σ_F is the yield strength corresponding to the beginning of permanent set, and ψ is the reduction in cross-sectional area at failure. The variation of tensile strength, of ψ, and of $\tan \gamma$ is next plotted as a function of carbon content ranging from 0.1 to 0.9% for twenty different plain carbon steels, with a variety of microstructures corresponding to the condition as received, and

to three different types of heat treatment. The plots bring out the effects of type of carbide, and of pearlite structures on the strength and strain-hardening properties of the steels.

W. Ramberg, USA

123. **Imai, Y., and Kumada, K., Study on high chromium steels. I. On the anomaly of a solid solution of Fe-Cr system at high temperatures,** *Sci. Rep. Res. Inst. Tohôku Univ. Japan* (*A*) 5, 3, 218–226, June 1953.

The cause of the so-called 475 C brittleness of a high-chromium steel has not yet been determined. To study this phenomenon, the hardness, thermal expansion, electric resistance, thermal magnetic analysis, tensile test, and microstructure of high-chromium steels containing 15 $\sim$ 35% of chromium were observed. When high chromium steels were heated at about 500 C, expansion was observed and the hardness and tensile strength increased, whereas the reduction of area, elongation, electric resistance, and intensity of magnetization decreased and the magnetic transformation point shifted toward higher temperatures with the time. Clear difference in microstructure was not seen between the specimens annealed for many hours at about 500 C and those annealed not so long, the former showing clear grain boundary etching. From these experimental results, it was concluded that this phenomenon was not caused by the usual precipitation but by the formation of a superlattice. From authors' summary

124. **Holdt, H., Creep resistance of steels for high-temperature use** (in German), *Schweiz. Arch.* 19, 4, 99–105, Apr. 1953.

For temperatures above 450 C, usual creep tests of two days are generally not sufficient to predict creep behavior during several years of service. High stressed bolts, for instance, instead of creeping, often fracture in a brittle way, frequently along the grain boundaries. In view of this, author made a series of creep-to-rupture tests on six low-alloy creep-resisting steels. Time to rupture varied between 0 and more than 10,000 hr. Load and elongation at fracture were plotted against time to rupture. One of the steels, which was known to behave sometimes brittle in service, behaved brittle in the tests too, but then only at relatively high loads (30 kg/mm^2), corresponding with a time to rupture of about 1000 hr. At moderate loads (20 kg/mm^2 and lower), corresponding with times to rupture of 10,000 hr and more, no embrittlement could be detected. In most cases, fracture-loads corresponding to creep lives of 10,000 hr and more could have been predicted through extrapolation of test data up to 1000 hr. One exceptional steel which behaved against this rule, was found to undergo changes in the microstructure (precipitation of a ferrite network). In practice, however, the tolerable deformation is always lower than the elongation at fracture of creep-to-rupture tests. Therefore, in constructional design, the criterion is not the load to rupture or the elongation to rupture but the total elongation due to creep during the desired time of service. According to author's opinion, this quantity can be predicted from 1000-hr tests with sufficient accuracy. In additional experiments, bending and tension are compared. At the same nominal loads, creep is much less in bending than in tension, probably due to a supporting action by the lower stressed inner fibers in the bend specimen. J. H. van der Veen, Holland

125. **Fast, J. D., and Meijering, J. L., Anelastic effects in iron containing vanadium and nitrogen,** *Philips Res. Rep.* 8, 1, 1–20, Feb. 1953.

Although this paper belongs to the field of solid state physics, it describes experiments on internal friction that are of interest to engineers. The results are shown in curves where the logarithmic decrement is plotted against the temperature. Very pure iron containing only 0.1 atomic per cent N shows a sharp maximum in the decrement at 21.5 C. The addition of 0.5% Mn shifts this maximum to 32 C and also causes a broadening of the peak. It is thought that this broadening may be due to the superposition of two simple peaks. By the simultaneous presence of both vanadium and nitrogen in otherwise very pure iron, a damping curve having two separate peaks is obtained. The effect of various heating and cooling programs upon the shape of the damping curve is shown.

These phenomena are discussed in terms of diffusion of interstitial atoms, binding energies, and the presence of abnormal interstitial sites in the presence of periodic elastic strain.

E. A. Davis, USA

126. **Hajto, N., The effect of heat treatment on the strength properties of cast iron treated with magnesium** (in Hungarian), *Öntöde* 3, 1, 1–18, Jan. 1952.

The domestic production of nodular graphite cast iron started with the use of Mg-Cu-Si alloy (10% Mg, 5% Cu); however, its toughness was not satisfactory due to the brittleness caused by Si. Even under these conditions two valuable properties of the Mg proved effectual: desulphurization, and the carbide stabilizing effect. Two series of experiments are described for alloying pig iron with a low and high Si content, respectively, with a small amount of Mg (approximately 10%). The obtained results are described and supplemented with a large number of illustrations. *Courtesy of Hungarian Technical Abstracts* I. Balsay

127. **Teed, P. L., Titanium—a survey,** *J. roy. aero. Soc.* 57, 508, 189–214, Apr. 1953.

128. **Jones, E. R. W., and Munro, W., The "elastic hysteresis" of uranium,** *J. Mech. Phys. Solids* 1, 3, 182–188, Apr. 1953.

Up to 300 successive static tension or compression loadings were applied to wrought and/or cast uranium specimens of various grain sizes and orientation. Hysteresis loops were recorded and their areas measured. Damping energy was influenced by metallurgical condition and mechanical history of the metal, but was generally by a factor of 10 greater than that shown by steel and brass in similar tests.

Authors conclude that energy dissipation in stress cycling is primarily due to mechanical twinning.

N. H. Polakowski, England

129. **Lardner, E., The formation of intracrystalline voids in solution-treated magnesium-aluminium alloys,** *J. Inst. Metals* 81, 439–442, 1952–1953.

130. **Findley, W. N., Combined-stress fatigue strength of 76S-T61 aluminum alloy with superimposed mean stresses and corrections for yielding,** *NACA TN* 2924, 90 pp., May 1953.

Introduction of combined stress conditions into study of fatigue increases complexity of an already complicated problem but may lead to information regarding basic nature of fatigue. This paper presents results of over 200 tests conducted on early vintage 75S-T6 forging alloy in cantilever bending, torsion, and four combinations of bending and torsion with several variations of ratio of mean to maximum stress. Tests were conducted on five modified Krouse machines providing constant amplitude of deflection; loading was based on elastic properties with analytical correction for effects of yielding where necessary.

A competent analysis of the data is presented, with examination of the suitability of applying various theories of strength under combined stress to failure in fatigue. Conclusions are that energy theories appear inadequate; most promising criteria are

principal shear stress corrected for anisotropy, the complete Guest law, and principal strain corrected for anisotropy. Other interesting conclusions concern significance of the mean stress component, the shear character of initial fracture under combined stress, nature of crack propagation, and possible effects of anisotropy.

Tests were apparently conducted in 1942–1945 and, as usual in retrospect, were limited in number, in definition of many material properties significant to behavior under combined stresses exceeding the elastic limit, and in control of test factors contributing to scatter. Nevertheless, analysis is thoroughgoing and contributory to the increasing store of information on fatigue processes.

P. E. Sandorff, USA

131. Backofen, W. A., and Hundy, B. B., Mechanical anisotropy in some ductile metals, *J. Inst. Metals* **81,** 433–438, 1952–1953.

Fracturing test specimens in tension after prestraining in torsion has shown that a fibrous cracklike structure, causing a considerable degree of mechanical anisotropy, exists in 70:30 brass, nickel, Monel metal, and Armco iron. The same program of testing has also revealed the presence of such a structure in high-purity aluminum, but, for reasons that are not clear, the tensile behavior of torsionally prestrained commercially pure (2S) aluminum gives no indication of its presence.

From authors' summary

132. Domagala, R. F., McPherson, D. J., and Hansen, M., Systems zirconium-molybdenum and zirconium-wolfram, *J. Metals* **5,** 1, 73–79, Jan. 1953.

133. Tests of blends of portland cement with masonry cement, *Wwys. Exp. Sta. tech. Memo.* 6-359, 23 pp., 13 tables, May 1953. $1.

Report presents chemical and physical test data related to strength, workability, and durability of paste, mortar, and concrete prepared with Portland cement, three masonry cements, and blends consisting of 75% Portland cement and 25% of each of the masonry cements. Masonry cements had limestone base, natural cement base, and slag base. Data indicate that Portland-cement concrete is generally superior to the blended cement except in factors related to durability. J. E. Goldberg, USA

134. Crawley, W. O., Effect of vibration on air content of mass concrete, *J. Amer. Concr. Inst.* **24,** 10, 909–920, June 1953.

135. Fulton, F. A., The principles and development of prestressed concrete, *Trans. S. Afr. Instn. civ. Engrs.* **3,** 6, 167–179, June 1953.

136. Steele, R. K., Review of research in prestressed concrete, Proc. Western Conf. Prestressed Concrete, Univ. of Calif., Los Angeles, Nov. 1952; 169–184, Jan. 1953.

137. Somogyi, K., Investigations on the surface hardness of concrete (in Hungarian), *Mélyépítéstudományi Szemle* **2,** 5, 249–255, May 1952.

A continuous and well-defined relation exists between the cube strength and surface hardness of concrete on the basis of which the index of the latter may furnish characteristic data in respect to the quality of the concrete. The method of measuring surface hardness developed by the author as well as the apparatus designed by him are based on Soviet experiences. A rotating tapered needle of determined size and material penetrates under a given pressure into the mortar on the surface of the concrete sample. The penetration readings may be taken with an accuracy of 0.01 mm. The result of the test carried out on concrete samples of varying age, mix, method of compacting and curing can be expressed by the following formula: $\sigma_k = k_b^{4/3}$, where σ_k denotes the cube strength in Kg/mm², b the depth of penetration of the needle in mm, k the factor depending on the type and grading of the aggregate and the method of compacting. Comparative measurements of surface hardness and cube strength, carried out on different types of concrete, indicated the k factor to be 0.45 on the average. The same tests showed further that the relation between cube strength and surface hardness is defined by the constant 0.776.

Courtesy of Hungarian Technical Abstracts K. Somogyi

138. Thornton, J. C., Relation between bond and the surface physics of masonry units, *J. Amer. ceram. Soc.* **36,** 4, 105–120, Apr. 1953.

It was noticed that many brick had high capillarity on rough or sanded surfaces and little or none on others. This led to bond tests during which it became evident that there was a relation between the kind of surface on a unit and the amount of bond.

Further experiments with chimneys or wells showed that (1) leakage and extent of dye penetration coincided closely with the previous laboratory bond tests; (2) there was excellent bond and practically no dye penetration with smooth brick which had little or no capillarity; (3) bond decreased and dye penetration increased according to the surface; and (4) as the capillarity of the surface increased, the bond decreased. It became apparent that, while there are differences in mortars in respect to bond, these differences are rather small when compared with the effect caused by the surfaces of masonry units.

From author's summary

139. Lash, S. D., Ultimate strength and cracking resistance of lightly reinforced beams, *J. Amer. Concr. Inst.* **24,** 6, 573–582, Feb. 1953.

Beams are of rectangular cross section, concrete strengths of 2000 and 4000 psi, steel percentages from zero to 1.2%. Specimens are 5.8 in. wide by 5.25 in. deep by 6 ft-6 in. span; $^1/_4$-in. diam plain reinforced bars have 43 ksi yield. Short duration (static) loading at third points. At very small steel percentages the ultimate strengths are much higher than predicted by theories which neglect concrete tension—the discrepancy diminishing to about 10% at normal percentages. Tensile modulus of rupture increases 100% from steel percentage zero to unity. At very low steel percentages, cracking is primarily a function of concrete strength; above certain steel percentages cracking is independent of concrete strength, and ratio of cracking load to ultimate load is essentially constant. Beam deflection at steel yield is constant for steel percentages above 0.7%; deflection at steel yield is very much less at smaller percentages.

M. J. Holley, Jr., USA

140. Paez, A., Characteristic strength of concrete (in Spanish), *Inform. Construc.* **5,** 47, 6 pp., Jan. 1953.

Conditions of "characteristic strength" of concrete are studied and theoretically analyzed. Usually the average strength is indicative for permissible stresses and safety factors of a structural material. It is emphasized that the extreme values of these factors (the range between minimum and maximum) for materials which are not homogeneous are of great importance. Criteria are presented to be used for determining characteristic strength of concrete based upon six and more test results, whereby, essentially, the extreme strength values are not taken into full consideration. J. J. Polivka, USA

141. **Beatty, J. R., and Juve, A. E., Stress relaxation in compression of rubber and synthetic-rubber vulcanizates immersed in oil,** *Trans. ASME* **75,** 4, 605–611, May 1953.

Four rubber stocks—natural, GR-S, neoprene GN, and Hycar OR-15, all loaded with furnace black—were immersed in three different ASTM test oils. Stress relaxation of the samples in compression was followed at different temperatures from 24 to 90 C over periods of time up to 10^4 hr, while swelling in the oil continued and approached equilibrium. The relative stress plotted against logarithm of time showed a monotonic and often nearly linear decrease up to about 100 hr, which did not differ greatly from the course of stress relaxation in air. After 100 to 1000 hr the relative stress usually increased and was always higher than the corresponding value for relaxation in air. This behavior is attributed to the force developed by swelling in the oil under partially confined conditions; it can be correlated with the volume increase observed in unconfined swelling, as related to the chemical nature of the rubber and the grade of the oil.

J. D. Ferry, USA

142. **Philippoff, W., Mechanical investigations of elastomers in a wide range of frequencies,** *J. appl. Phys.* **24,** 6, 685–689, June 1953.

The paper describes measurements of the shear moduli and energy losses for elastomers in isothermal deformation over a frequency range of 10^6; this is a range some 10^4 times greater than previously investigated. The materials tested were natural rubber, polyvinylchloride, and Thiokol prepared in specimens 1 in. × 1 in. × $^1/_4$ in. Specimens glued or vulcanized to flat plates were subjected to an oscillatory shear strain by a mechanical cam drive with variable stroke up to 4000 micron and frequency from 13 cps to 6×10^{-1} cps. Simultaneous measurement of the driving force and deformation gave a hysteresis loop from which the essential data were obtained. The tests show mechanical properties of elastomers to vary greatly with frequency; this result should be considered in using these materials for a particular engineering application. J. M. Krafft, USA

143. **Werren, F., Mechanical properties of glass-cloth plastic laminates as related to direction of stress and construction of laminate,** *Trans. ASME* **75,** 4, 613–619, May 1953.

Author treats theory of the elastic properties of orthotropic materials, i.e., materials having three mutually perpendicular planes of elastic symmetry. Expressions for relevant moduli in tension, compression, and shear of such materials are given and are related to tests on composite or cross-laminated glass-cloth plastic laminates. Reasonable agreement is obtained between theory and experiment. H. Kolsky, England

144. **Freas, A. D., Effect of preloading and fatigue on mechanical properties of glass-cloth plastic laminates,** *Trans. ASME* **75,** 4, 621–633, May 1953.

Paper gives results of tensile tests on glass-cloth plastic laminates made from both "square" (similar properties in warp and filling) and unidirectional fabrics laminated with alkyd-styrene resins. Effect of preloading above the proportional limit on ultimate strength modulus was observed. Modulus of preloaded specimens was diminished and tended toward the secondary (high load) modulus observed with initially loaded laminates. The tensile strength did not appear to be affected by preloading. Effect of repeated loadings (fatigue) was also observed. Fatigue strength at 10^7 cycles was between 20 and 30% of static tensile strength. When the mean stress about which the fatigue cycle was made was raised, the amplitude of the alternating stress to cause failure (after 10^6 cycles) was sharply reduced. No theoretical discussion is given. K. W. Hillier, England

145. **Freas, A. D., and Werren, F., Supplement to "Mechanical properties of cross-laminated and composite glass-fabric-base plastic laminates,"** *For. Prod. Lab. Rep., U. S. Dept. Agric.*, no. 1821-A, 18 pp., Mar. 1953.

The physical properties of glass-fabric laminates may be altered by using different glass fabrics for the laminations or by varying the orientation of the laminations. The question arises of predicting the properties of an arbitrary laminate from corresponding properties of simply constructed laminates. Report describes experiments [see AMR **5,** Rev. 143] in which the measured mechanical properties of composite parallel-ply laminates with different proportions of two glass fabrics are compared with values calculated from data for the simple parallel-ply laminates. Tests included were tension, compression, flexure, and panel shear.

The calculated values were derived by several methods. Methods giving predicted values in closest agreement with measured values were, in general, the same as reported previously (see reference cited). B. M. Axilrod, USA

146. **Werren, F., Supplement to "Mechanical properties of plastic laminates,"** *For. Prod. Lab. Rep., U. S. Dept. Agric.*, no. 1820-A, 25 pp., Feb. 1953.

This report presents the results of tension, compression, bending, and shear tests of six parallel-laminated glass-fabric-base plastic laminates. The data supplement those of a previous report of the same title [title source, Rep. no. 1820; AMR **4,** Rev. 4159] in which results of tests of 14 laminates were given.

Tests of the laminates were made after both normal and wet conditioning. The mechanical properties of the laminates, both dry and wet, are presented in the form of tables and by average stress-strain curves.

From author's summary by L. W. Hu, USA

147. **Samuels, L. E., The use of diamond abrasives for a universal system of metallographic polishing,** *J. Inst. Metals* **81,** 471–478, 1952–1953.

148. **Sulser, H., Theoretical considerations in the evaluation of yarn unevenness** (in German), *Schweiz. Arch.* **19,** 3, 85–96, Mar. 1953.

Nonuniformity in fiber assemblies arises from random variation in number of fibers in the cross section, and in length and diameter of fibers, plus systematic variations introduced by processing. To separate these effects and thereby discover nonuniformities introduced by machines, the theory of the combination of these variations is studied. The results are applied to experimental data obtained with the Uster evenness tester on sliver, roving, and yarn, both carded and combed. Further analysis takes into account the effect of finite sample length and width of measuring plate. It is shown that for the Uster tester the error introduced thereby is negligible. It is further shown how the effect of finite sample length decreases the response of the tester to sinusoidal nonuniformities of wave length greater than sample length. Finally, it is pointed out that the harmonic analysis of an unevenness record may show a spurious periodicity due not to nonuniformity introduced by machinery, but merely from the peaked Fourier decomposition of the random variations. D. J. Montgomery, USA

149. **Radford, J. F., and Waldvogel, R. K., Quality control of resistance welding by statistical methods,** *Weld. J.* **32,** 6, 521–526, June 1953.

Procedure necessary for construction of quality control charts is given in some detail and will be of value to the welding engineer

who has had little experience in statistical methods. This information can be found in most elementary books on statistics, but the report will be of interest to aircraft firms desirous of introducing quality control in the assembly of spot-welded components. A useful list of references and a bibliography are included.

Report is a simple but useful contribution to the literature on statistical methods applied to resistance welding.

H. E. Dixon, England

Mechanics of Forming and Cutting

(See also Rev. 31)

150. Keel, C. G., Investigations on admixture materials for autogenous welding (in German), *Schweiz. Arch.* **19,** 4, 5; 113–133, 153–167; Apr., May 1953.

Welding by a gas flame ordinarily will give so much hydrogen in the seam that the material, by an impact-tensile test, will be of inferior quality to a seam produced by electric welding. Paper describes a series of tests made in Switzerland after World War II. Purpose: Better gas weldings. Author found thereby that contents of hydrogen may be reduced (1) by special welding rods, (2) by reheating of every 10 cm of the hot seam. At 900 C the hydrogen by diffusion will go out of the seam in a very short time but it will take almost a year when the seam is cold.

A. R. Holm, Denmark

151. Almási, Gy, and Devecseri, J., Electrical welding of carbide tool tips (in Hungarian), *Gép* **4,** 4, 191–192, Apr. 1952.

A report on experiments conducted on the electrical welding of carbide tool tips and a description of a device by means of which shell-like cracks—which form on the tool tips shortly after they are put into use in the event they had been mounted either by a welding gun or in a tempering furnace or by any other means—have been eliminated and the welding time reduced from 15–20 min to 40–50 sec. The most important part of the device is a 12 kVA transformer with 13 primary taps which permits a secondary voltage regulation from 1.5 to 3 volts at a 4000-amp load to suit tools of various thickness. Heating is effected between water-cooled copper electrodes, one of which is stationary and the other adjustable. A pedal-operated tool rest is arranged between the electrodes and the current switched on by another pedal.

Courtesy of Hungarian Technical Abstracts R. Erdös

152. Nagy, M. S., Investment casting of high-speed steel tools (in Hungarian), *Magyar Technika* **7,** 3, 4; 116–118, 204–207, Mar., Apr. 1952.

The casting of high-speed steel milling cutters and other tools of intricate designs by melting the steel in a small tilting electric arc furnace and by pouring it directly into special molds has been elaborated and put into practice about a year ago at the Mátyás Rákosi Works. This method is similar to the wax-impression method used by sculptors, jewelers, and dentists; however, this method can be applied for high-speed alloys with a high melting point only since adequate fireproof molding materials, the polymerization products of ethyl silicate, have been found. A master pattern is made of bronze or steel and a mold, cast of metal with a low melting point, is taken of the pattern. Wax is poured into the mold and the finished wax pattern is coated with a thin (0.5 mm) layer of fine-grained hydrolized ethyl silicate. This is bedded either in a molding material of similar composition or, having thickened the coating to 2–3 mm by dipping or spraying, in molding and quartz sand. Subsequently, the wax is melted and poured out, the mold heated to 900–950 C; this transforms the ethyl silicate into silicate and the mold hardens. The molding box is clamped with its sprue downward on the discharge outlet at the top of the furnace and the molten alloy is poured into the mold by tilting the furnace. The process is relatively expensive; however, the tools obtained from the mold are true to size with a tolerance of 0.02 to 0.05 mm per cm and ready for sharpening; a 50 to 60% economy in material may be realized compared with metal-cutting methods; chips can be melted down and tools have a long life. Detailed data are furnished on the equipment, best molding materials, and steel alloys.

Courtesy of Hungarian Technical Abstracts R. Erdös

153. Opitz, H., and Hucks, H., The cutting process as a problem of the theory of gliding surfaces in a two-dimensional and three-dimensional state of stress, according to Mohr's theory (in German), *Werkstattstech. Maschinenb.* **43,** 6, 253–260, June 1953.

Stress analysis of the orthogonal and oblique cutting processes is presented. Relationships for the principal stresses in the shear zone, the direction cosines for the total stress, the shear angle, and angle of maximum deformation are derived, based on Mohr's theory of flow. Formulas are given for the coefficient of friction and for transforming the three measured components of cutting force into another set of three mutually perpendicular components of force.

Article presents an original and very interesting approach to the problem of the mechanics of metal cutting.

D. Kececioglu, USA

154. Thomsen, E. G., Lapsley, J. T., Jr., and Grassi, R. C. Deformation work absorbed by the workpiece during metal cutting, *Trans. ASME* **75,** 4, 591–598, May 1953.

From the study of photomicrographs of machined surfaces, authors conclude that deformation work absorbed in the surface layer of the workpiece is not negligible and that it may become significant when the chip thickness is small. Intercept of the cutting-force curve at zero depth of cut gives a first approximation of the "equivalent" force responsible for the deformation energy. In analyzing cutting data, proper account can be made by subtracting such force intercepts from the nominal cutting forces measured with a tool force dynamometer. Results thus obtained tend to support Merchant's minimum energy theory of chip formation.

Reviewer believes that the approximate method of correction suggested in the paper will be useful in interpreting machining data. However, authors' analysis involves many speculative assumptions, the validity of which remains to be seen.

B. T. Chao, USA

155. Bickel, E., Present state of research on cutting processes (in German), *Schweiz. Arch.* **19,** 4, 105–113, Apr. 1953.

Methods and results of metal-cutting research in various countries are analyzed in regard to their practical importance. Temperature distribution in tool point, chip formation, and microstructure in relation to "machinability" are discussed, as well as factors like cutting speed, composition of tool materials, and friction phenomena.

A. O. Schmidt, USA

156. Hahn, R. S., Some observation on chip curl in metal-cutting process under orthogonal cutting conditions, *Trans. ASME* **75,** 4, 581–587, May 1953.

An experimental study was made of the transient behavior of chip curl. It was found that the chip curvature was independent of speed and not greatly affected by a change in rake angle. As the depth of cut increased, the curvature of the chips decreased.

Equilibrium, however, was reached in the same length of travel. Temperature equilibrium was reached within 0.13 in. of travel.

Based on the evidence presented in the paper, it was concluded that chip curl originates in the shear region and that the phenomenon is thermal in nature. Several hypotheses were made to explain chip curl.

Reviewer would like to call attention to the fact that Fig. 9 of the paper does not satisfy stress boundary conditions along *EF*. However, since this figure plays a relatively unimportant role on the concepts presented, this error should not detract from the relative importance of the paper. B. W. Shaffer, USA

157. **Hahn, R. S., On the temperature developed at the shear plane in the metal cutting process,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 661–666, 1952.

The distribution of thermal energy associated with the shearing process in metal cutting is considered by treating the material as a continuum and the strain that is produced in forming a chip as homogeneous. The equations are developed for the temperature distribution in the vicinity of a band heat source moving obliquely through an infinite solid and the results applied to the shear plane. The results are presented in nondimensional form. The calculated shear-plane temperature is shown to be reasonable by comparing it with the results of approximate calculations and calorimetric measurement. M. C. Shaw, USA

158. **Stau, K. H., Some thoughts on the further development of "copy turning"** (in German), *Werkstatt u. Betrieb* **86,** 4, 163–166, Apr. 1953.

Formulas are derived for calculating the time required to remove material when lathe-turning various geometric shapes in copying work. The time is calculated when cutting with a constant surface cutting speed and when cutting with a constant lathe rpm. It is shown that great turning-time savings may be had when provisions are made to maintain a constant surface cutting speed. Hydraulic and manual copy-turning methods are described and formulated. The necessity of building sturdier lathes with stronger drive mechanisms is stressed.

D. Kececioglu, USA

159. **Hultzsch, E., Application of the three-wire method to unsymmetrical threads** (in German), *Feingerätetech.* **1,** 2, 3; 92–94, 133–137; May, June 1952.

The quality and inner dimensions of a screw thread may be determined with the help of three wires, two of which are placed in the thread in two consecutive turns, the third one in a position parallel to the plane of the two former wires in the thread at the opposite side of the screw. Thicknesses and mutual distances of the wires give information on the thread. The method may give erroneous results if attention is not paid to a number of numerical conditions which are derived by a mathematical treatment.

C. Zwikker, Holland

160. **Saljé, E., Theoretical foundations of the process of grinding** (in German), *Werkstatt u. Betrieb* **86,** 2, 4; 45–56, 177–182; Feb., Apr. 1953.

This paper presents a considerable amount of experimental and analytical work on the variables involved in the grinding process from the point of view of surface finish and the forces involved. Dimensional analysis is used to derive significant groups of variables and results in the introduction of thermal conductivity as a new factor. E. G. Loewen, USA

161. **Crawford, J. H., and Merchant, M. E., The influence of higher rake angles on performance in milling,** *Trans. ASME* **75,** 4, 561–566, May 1953.

See AMR **6,** Rev. 1293.

Hydraulics; Cavitation; Transport

(See also Revs. 82, 260, 318, 338, 339)

162. **Eisenberg, P., A brief survey of progress on the mechanics of cavitation. An addendum to DTMB Report 712, On the mechanism and prevention of cavitation,** *David W. Taylor Mod. Basin Rep.* 842, 24 pp., June 1953.

Presentation of a unified outline of the various cavitation processes. Outline of progress on these topics from 1950 to 1953.

E. F. Macks, USA

163. **Tulin, M. P., Steady two-dimensional cavity flows about slender bodies,** *David W. Taylor Mod. Basin Rep.* 834, 21 pp., May 1953.

Author discusses linearized theory for two-dimensional cavity flow about a slender symmetrical body. Boundary conditions for velocity potential on symmetry axis are (1) normal derivative proportional to body slope on body, (2) tangential derivative proportional to cavity number on cavity, and (3) integral of normal derivative along body and cavity vanishes (closure condition). Assuming source distribution along symmetry axis, integral equation is solved by thin-airfoil theory methods. Solution is rendered unique by "juncture" condition at body-cavity junction; flow must be smooth, i.e., slope of cavity equals body slope. In spite of Brillouin's paradox in linearized theory, solution exists because it is invalid near cavity end. Cavitation drag is computed. Infinite cavity case (cavity number 0) is considered and shows asymptotic behavior, as in exact theory. For finite cavity, cavity shape is essentially elliptic. For slender wedge (wedge angle 30°), results are compared with available exact results and show (for a linearized theory) acceptable agreement.

R. Timman, Holland

164. **Messerle, H. K., Electronic high speed simulation of hydraulic problems,** *J. Instn. Engrs., Austral.* **25,** 3, 35–41, Mar. 1953.

An electronic high-speed simulator has been developed at the University of Melbourne for the solution of the pondage equation relating the water flow and the water level in a reservoir. The instrument has been used for the investigation of general flood-routing problems and is described in this paper.

The solution of more complex hydraulic problems is investigated also, and it is shown that the principles used for the simulation of the pondage equation can be extended quite readily to the analysis of general hydraulic systems.

From author's summary

165. **Szesztay, K., Statistical methods in engineering hydrology** (in Hungarian, with Russian and English summaries), *Vízügyi Közlemények* no. 1, 119–157, (18)–(20), 1953.

This well-written review paper discusses fundamental western contributions as further developed in recent Russian papers. After a comprehensive summary of basic concepts in statistics (mean: M; variation: C_v; weakness: C_s; and peakedness: E), Pearson's and Chavlier's distribution functions are discussed. The former (recommended by author) contains three and the latter, four parameters. Integrating Pearson's function [C. Pearson, "Statistical methods," 1914] author tabulates the

probability curve following Foster [*Trans. Amer. Soc. civ. Engrs.* **87**, 142–203, 1924] and Ribkin. Methods for finding M, C_v, and C_s from observation data are discussed, pointing out the importance of quality and quantity of original data. Detailed discussion is given of the problem of partial or complete lack of observation data; analogy methods using extrapolations based on regression lines [A. B. Ogievsky's book, "Hydrology," Moskva, 1951] and various empirical formulas (P. S. Kuzin and M. E. Sevelev) are critically reviewed.

Many numerical examples are presented and different methods compared. Carefully translated figure and table captions and lengthy English abstract make paper accessible without knowledge of the Hungarian language. Although not referenced in paper, reviewer also suggests Mead's book [AMR **3**, Rev. 1809].

V. G. Szebehely, USA

166. Gibrat, R., Maximum flood discharge and probability calculations (in French), *Trans. Fourth Congr. Inter. Comm. Large Dams*, New Delhi, Jan. 1951, in 4 vols., vol. II, 643–660. $48 per set.

167. Anonymous, Channel improvements, Farm Creek, Illinois, *Wwys. Exp. Sta. tech. Memo.* no. 2-355, 27 pp., Feb. 1953.

Report of a hydraulic model investigation conducted by the Hydraulics Division of the Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss., to test the proposed channel improvements designed to prevent damage from flash floods in the lower reaches of Farm Creek, a tributary of the Illinois River, near the city of Peoria, Ill.

After a statement of the problem on the prototype, the definite project plan is explained, followed by a description of the fixed-bed-type model built at an undistorted linear-scale ratio of 1:60. The various tests conducted on the model are described and all the measurements of water surface elevations and water velocities are presented in tabular form. Eleven plates present various profiles and details of the structures as originally designed and as modified to improve the flow conditions. Final conclusions and recommendations are clearly stated. Many good photographs show details of the model and flow conditions.

A. Leclerc, Canada

168. Laursen, E. M., Observations on the nature of scour, Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 179–197, 1953.

169. Harrison, A. S., Deposition at the heads of reservoirs, Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 199–225, 1953.

170. Vanoni, V. A., Some effects of suspended sediment on flow characteristics, Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 137–158, 1953.

On the basis of experiments by the writer and others, it is concluded that suspended sediment damps the turbulence of the flow in such a manner that both the exchange coefficients, ϵ_m for momentum and ϵ_s for sediment, are reduced as the sediment concentration is increased. The friction factor of flow tends to be reduced when ϵ_m is reduced, but is increased by dunes forming at the bed. This means that the friction factor of sediment-laden flow may increase or decrease with sediment load, depending on which of these factors is the larger.

The accepted theory of suspended load, while being very useful in analyzing sediment transportation problems, is inadequate to account for the effects of the sediment on the flow.

From author's summary by Dwight F. Gunder, USA

171. Wicker, C. F., The transportation and deposition of sediments in estuaries, Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 227–241, 1953.

172. Bélteky, L., Specifications for well drilling and their influence on well life and output (in Hungarian, with Russian and French summaries), *Vízügyi Közlemények* no. 1, 78–79, (14)-(16), 1953.

Incompressible Flow: Laminar; Viscous

(See also Revs. 226, 228, 253, 274, 285, 289, 309)

173. Hurd, C. W., Chesky, K. P., and Shapiro, A. H., Influence of viscous effects on impact tubes, *J. appl. Mech.* **20**, 2, 253–256, June 1953.

Experimental results are presented for the stagnation pressure of a viscous, incompressible flow. The data were obtained with a blunt-nosed hypodermic tube (0.072-in. OD and 0.053-in. ID) at the end of a 5-ft arm, rotating in a circular towing tank which contained liquids of various viscosities. The probe speed varied from 0.5 to 16 fps and gave a Reynolds number (Re) range from about 0.8 to 4000 (based on the tube radius).

The results show that the pressure coefficient $C_p = (p_0 - p)/\frac{1}{2}\rho V^2$ (where p_0 is Pitot pressure, p static pressure, V free-stream velocity, and ρ density) is unity beyond a Reynolds number of 1000, and the effects of viscosity on the Pitot pressure are negligible. For $50 < Re < 1000$, C_p is less than unity, and for $0.8 \leq Re < 50$, C_p increases monotonically beyond unity (for $Re < 1$, $C_p = 5.6/Re$).

The experimental results of earlier investigators (Barker and Honan) are also discussed.

The effect of viscosity on Pitot tube readings at low Reynolds numbers is again clearly demonstrated. The authors point out that an exact theoretical treatment has not been obtained to date. The importance of this effect at hypersonic flows and for boundary-layer surveys is also stressed.

The reviewer would like to refer to *NACA TN* 2995, Sept. 1953, by F. S. Sherman, where detailed experimental data of this phenomenon are presented for supersonic and subsonic flows. It is noted that the present results are in better agreement with the results presented by Sherman for the supersonic rather than the subsonic flow regime, for a similar blunt Pitot tube. Sherman also demonstrates the considerable effect of tube shape on Pitot readings at low Reynolds numbers. I. I. Glass, Canada

174. Stewartson, K., On the slow motion of an ellipsoid in a rotating fluid, *Quart. J. Mech. appl. Math.* **6**, part 2, 141–162, June 1953.

The slow motion of an ellipsoid in an inviscid fluid rotating about an axis of the ellipsoid is considered by perturbation method. Formal solution is given for the perturbation at any time and is used to find the ultimate velocity distribution when the ellipsoid is moving with uniform velocity. The velocity is steady in general and markedly different in the two regions separated by a cylinder enclosing the ellipsoid and having its axis parallel to the axis of rotation of the fluid. The motion of the ellipsoid in both the directions parallel and perpendicular to the axis of rotation is considered. The linearized theory yields infinite velocities at the circumscribing cylinder, and it is shown how viscosity would modify this. G. V. R. Rao, USA

175. **Wakiya, S., A spherical obstacle in the flow of a viscous fluid through a tube,** *J. phys. Soc. Japan* **8, 2,** 254–257, Mar.-Apr. 1953.

The effect of a fixed spherical obstacle on the axis of a Poiseuille flow in a circular tube is calculated on the basis of the Stokes approximation. The force on the sphere and the additional pressure difference required to maintain the flow rate constant for all ratios of sphere diameter to tube diameter are calculated.

A. M. Kuethe, USA

176. **Serrin, J., On plane and axially symmetric free boundary problems,** *J. rational Mech. Anal.* **2,** 3, 563–575, 1953.

Paper makes applications of comparison theorems for inviscid incompressible flows by presenting results of a qualitative nature for the major problems of free boundary flow, the cavity behind a given obstacle, and the free jet issuing from a channel. The results concern plane symmetric and axisymmetric flows. Four theorems are proved. Theorem 1 removes any doubt concerning "pathological behavior." Theorem 2 compares the shapes of cavities or jets formed by different obstacles or channels and provides an alternative method of establishing uniqueness of free boundary flows, including those with axial symmetry. This theorem is particularly elegant. In terms of plane jets, let T_1 be the upper channel wall terminating at A and let Σ_1 be the free streamline springing from A. Call the whole region of flow R_1. Consider a second flow in which the upper channel wall T_2 also terminates at A, region of flow R_2. If T_2 is contained in R_1, then Σ_1 is contained in R_2. Theorem 3 states that, if the flux in a straight infinite channel is prescribed, then there can be no more than one symmetric flow past a given starlike obstacle. Theorem 4 determines the symmetric obstacle of given dimensions with least cavity drag.

L. M. Milne-Thomson, England

177. **Couchet, G., On the kinetic energy of a fluid and the calculation of the forces exerted by the fluid on a moving profile** (in French), *Rech. aéro.* no. 32, 10–13, Mar.-Apr. 1953.

In a previous paper [AMR **6,** Rev. 951], the author has derived expressions for the force and moment acting on a two-dimensional body moving in an arbitrary manner through a perfect incompressible fluid at rest at infinity. It is assumed that there is no vorticity and that the circulation is zero. These expressions are in terms of the coefficients of the conformal transformation of the given profile into a circle. Results are used in present paper to derive simple formulas for the longitudinal, transverse, and rotational inertia coefficients of the profile, from which kinetic energy and linear and angular momenta may be directly obtained.

L. Landweber, USA

178. **Wieghardt, K. E. G., On the resistance of screens,** *Aero. Quart.* **4,** part II, 186–192, Feb. 1953.

Author attempts to correlate available data on the resistance of screens by assuming that the significant velocity is the average one in the screen itself rather than the free-stream velocity. In spite of the apparent simplicity of this assumption, a fairly good collapse of the data is obtained for screens having a square mesh, except at the higher Reynolds numbers. As an average of these data, an approximate drag coefficient is given as $c \simeq 6\,(u_1 d/\beta\nu)^{-1/2}$ for Reynolds numbers $u_1 d/\beta\nu$ between 60 and 600. Here, $c = \beta^2 k/(1-\beta)$, $k = (p_1 - p_2)/{}^1/_2\rho u_1^2$, p_1 and p_2 are upstream and downstream pressures, resp., u_1 is upstream velocity, ρ is mass density, and ν the kinematic viscosity of the fluid, β (the porosity) is $(1 - d/l)^2$, d is the diameter of a single wire, and l is the width of the square mesh. No explanation for the large divergence of the data for Reynolds numbers greater than about 600 is suggested.

P. Eisenberg, USA

179. **Moon, P., and Spencer, D. E., Some coordinate systems associated with elliptic functions,** *J. Franklin Inst.* **255,** 6, 531–544, June 1953.

Useful cylindrical and rotational coordinate systems based on elliptic-function transformations are developed for physicists and engineers interested in solving electrostatic and hydrodynamic problems by separation-of-variables techniques. Properties are conveniently listed.

A. Charnes, USA

180. **Lyttleton, R. A., Stability of rotating liquid masses,** New York, Cambridge Univ. Press, 1953, vii + 150 pp., 19 figs.

The so-called fission process of formation of binary systems in celestial mechanics is of considerable interest from a cosmogonical standpoint, apart from the intrinsic mathematical and dynamical interest of the subject. Investigations along this line may constitute the only source of information on the question of how an isolated unstable rotating mass will develop. To solve the controversial problem whether the fission process is or is not the origin of satellite configurations in space, the author applies a very methodical and systematic approach. The basic point is the discussion of the theory of the stability of rotating gravitating liquids in order to determine the evolution of such systems. The author arrives at a conclusion which is contrary to that reached by many distinguished astronomers in the past: He argues that the dynamical evidence does not support the fission process. According to the fission theory, the origin of binary stars is due to the break-up of a single mass by its rotation. The so-called pear-shaped figure of a liquid rotating mass is an intermediary phenomenon in this process. By a methodical argumentation, the author proves in an elegant mathematical way that the pear-shaped figure is quite certainly secularly unstable. In this he makes considerable use of the previous results of Lyapunov and Jeans and of Darwin's original investigations. This simply means that the pear-shaped form itself never comes into existence, and the fission theory seems to be invalid. Hence, he proves on purely dynamical grounds that the process of instability cannot result in the formation of a double system consisting of two comparable masses moving in close orbital motion about each other. He shows that, after the process of break-up, the portions must be of considerably different sizes, and the smaller one must separate to infinity, i.e., it must escape entirely from the gravitational field of the larger one. He suggests that the great planets are the surviving main portions of such rotational disruptions of a number of larger primitive planets. The author puts forward his own hypothesis: It is not to be expected that the disruption itself would take place simply as a clear division into two separate parts. It seems that a stream of liquid mass would form stretched between the two main masses and would have a velocity between those of the main masses. Such a stream would not be a stable arrangement. As the main masses separate, it would break up into small masses. Some of them nearer the ends might have insufficient speeds to escape from the adjacent main mass. But the general rotation associated with the original mass would be maintained and endow each of these small masses with orbital angular momentum about it. It is in this way that larger residual portion might come to possess a system of small satellite masses which move about it at distances comparable with the size of the body itself and in the same general direction as that determined by the rotation of the main body.

After this general review, one may discuss briefly the particular chapters of the book. I. Introduction. II. Stability: A thorough discussion of stability conditions of a mechanical system. III. The spherical form: Stability of a spherical form for small displacements. IV. The spheroidal and ellipsoidal forms: The existence of the Maclaurin spheroids and Jacobi ellipsoids as possible equilibrium forms of the previous ones. V. Ellipsoidal

harmonic analysis: The elements of such an analysis. VI. Further properties of Lamé functions: Development of a function as a series of ellipsoidal surface harmonics, gravitational potential, etc. VII. The secular stability of the Maclaurin spheroids: Determination of stability for all small displacements. VIII. The secular stability of the Jacobi ellipsoids: Discussion of the Jacobi series forms of bifurcation, the stability of the pear-shaped figure, etc. IX. The ordinary stability of the Jacobi ellipsoids: Properties of Poincaré's equation, etc. X. Cosmogonical implications: The conclusions reached in this chapter were discussed previously.

The appendix contains the references. The book is excellently printed and certainly is an interesting contribution to the theory of cosmogonical phenomena. M. Z. Krzywoblocki, USA

Compressible Flow, Gas Dynamics

(See also Revs. 33, 209, 213, 218, 219, 229, 233, 236, 239, 259, 279, 280, 285)

181. de Groot, S. R., Hydrodynamics and thermodynamics, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 87–99, 1953.

Author treats the interdependence of fluid mechanics and the thermodynamics of irreversible processes. The four fundamental equations—conservation of mass and momentum and the first and second laws of thermodynamics—are developed for a system of several components subject to viscous flow, heat conduction, diffusion, external forces, and chemical reaction. The resulting entropy balance equation consists of a convection term and a source-strength term. The source strength is a function of the viscous flow, heat conduction, diffusion, and chemical reaction. Linear relations between the "fluxes" and "forces" are then introduced and some general conclusions about the nature of the coefficients are drawn. With the usual assumptions, the force equation reduces to the Navier-Stokes equation and part of the entropy source strength results from the Rayleigh dissipation function.

The work of Prigogine and Mazur on a two-fluid system that describes liquid helium II is discussed briefly. Finally, an interesting appendix on other forms of the four fundamental equations is given, and the possibility of new cross phenomena (visco-chemical effects) is suggested. This paper provides an interesting insight into fluid mechanics as viewed with the generality of modern thermodynamics. R. A. Gross, USA

182. Schaaf, S. A., Theoretical considerations in rarefied-gas dynamics, "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 237–260, 1953. $5.

Author has summed up the present status of knowledge in this field, which has assumed new importance with the development of high-altitude, high-velocity missiles. Both free molecule flow and slip flow are discussed. An examination of engineering application possibilities in wind-tunnel and heat-transfer problems is made. An extensive bibliography is included.

F. C. Hooper, Canada

183. Schaaf, S. A., Experimental methods and results in rarefied-gas dynamics, "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 261–282, 1953. $5.

The low-density wind tunnel in use at the University of California is described. Nozzle design and flow-visualization difficulties are reported. An electric discharge afterglow technique and a selective absorption technique for flow visualization are outlined. Tunnel calibration problems are reported.

Experimental heat-transfer data for both subsonic and supersonic flow at low densities are given and compared with theoretical data, as well as drag coefficients and over-all recovery factors for various basic model shapes.

Mention is made of a molecular beam apparatus and of a high-speed rotating-cylinder apparatus also in use which offer better controlled conditions for the examination of the interaction characteristics between gas molecules and surfaces.

An extensive bibliography is included.

F. C. Hooper, Canada

184. Carrier, G. F., and Yen, K. T., On the construction of high-speed flows, "Fluid Dynamics," Proc. Symp. appl. Math. vol. IV; New York, McGraw-Hill Book Co., Inc., 55–60, 1953.

An integral representation is given for solutions to the hodograph equation for stream functions of irrotational isentropic flow. The method consists in formally taking the Fourier transform of an incompressible flow and inverting that transform with a hypergeometric function instead of an exponential. Two examples are given. General properties of the flows are easily investigated, but detailed computations are probably as difficult as in any other method. S. H. Crandall, USA

185. Neice, S. E., A method for stabilizing shock waves in channel flow by means of a surge chamber, *NACA TN* 2694, 46 pp., June 1953.

The flow in a diffuser similar to that used in a double-throat supersonic wind tunnel was analyzed theoretically, using a modified method of characteristics which took account of the mass removal from the channel by means of the surge chamber. This was connected to the diffuser just upstream of the normal shock wave in the divergent part. The analysis indicated that the mass-removal technique effectively damped shock-wave motions caused by strong compression pulses originating downstream. Experiments showed quantitative agreement with this analysis and, furthermore, they indicated that the technique was effective in damping the oscillatory motion of the shock caused by continuous small, random, downstream disturbances.

N. H. Johannesen, England

186. Truesdell, C., Two measures of vorticity, *J. rational Mech. Anal.* **2, 2,** 173–217, Apr. 1953.

Author introduces two nondimensional measures of the "amount of rotation" in a fluid. The first, W_K, termed the kinematic vorticity number, is the ratio of the vorticity magnitude to the square root of twice the double inner product of the rate of strain tensor with its conjugate, while the second, W_D, termed the dynamic vorticity number, is the ratio of the magnitude of the vector product of the vorticity and velocity to the magnitude of the remaining terms in the expansion of the acceleration vector. The greater part of the paper is devoted to establishing somewhat academic theorems involving these vorticity numbers, and in particular to characterizing the class of motions for which W_K and W_D are unity. The following examples receive attention: Flow in a rotating cylinder, Beltrami motions, Gerstner's waves, simple vortex, Couette flow, and the rotation generated by a curved shock.

W_K appears to have little practical value, but since the condition $W_D \ll 1$ justifies neglect of the rotation term in the fluid motion equation, W_D may be of some interest to engineers. The rotation generated by a curved shock is studied in some detail, and the functional dependence of W_K and W_D on shock strength and angle is exhibited, although no practical conclusions are drawn.

Reviewer considers the paper's value would have been con-

siderably enhanced by a discussion of the practical significance of the vorticity numbers. In particular, an account of how the condition $W_D \ll 1$ could be applied to a given supersonic (or viscous) flow problem, in which W_D is usually unknown at the start, would have been most useful. L. C. Woods, England

187. **Lavender, R. E., A note on second-order supersonic flow theory,** *J. aero. Sci.* **20,** 6, 435–437, June 1953.

Note in Readers' Forum.

188. **Schafer, M., A unified method of characteristics for the treatment of mixed subsonic and supersonic flow** (in German), *J. rational Mech. Anal.* **2,** 3, 383–412, 1953.

Author expounds a new approach to mixed-flow problems, without shock waves, by means of a suitable generalization of the conception of characteristic variables. As is known, the proper characteristics ξ, η (termed principal characteristics) become complex in the subsonic region, say, $\xi = s + it$, $\eta = s - it$. By writing $s = (\xi + \eta)/2$, $t = (\xi - \eta)/2i$ one defines a pair of real variables, called by the author secondary characteristics. Evidently, in the supersonic region, one can introduce in an analogous manner $\delta = (\xi + \eta)/2$, $\tau = (\xi - \eta)/2$. Hence, a pair of real secondary characteristics can be used throughout the whole domain of flow. The first result of importance is that now the hodograph equations in terms of the secondary characteristics are the wave equation in the supersonic and the Laplace equation in the subsonic regions. General solutions thus can be given. Conditions at the sonic line, if supposed continuous, supply relations between those solutions.

Next, author discusses the relations between the characteristic variables and the geometric variables of the flow. He introduces for this purpose metric functions of the field and shows that they obey certain linear partial-differential equations in terms of the secondary characteristic variables. These equations are of hyperbolic type in the supersonic region and of elliptic type in the subsonic region. Their coefficients depend, however, on the solutions of the hodograph equations. The geometric variables follow then by simple quadrature. Author promises to publish separately an application of his method. Here only the well-known case of Ringleb (1940) is treated. Questions of existence and uniqueness of solutions are not discussed. The chief results of the present paper are the subject of a report delivered at Istanbul in 1952.

A. von Baranoff, France

189. **Miles, J. W., Impulsive motion of a flat plate,** *Quart. J. Mech. appl. Math.* **6,** part 2, 129–140, June 1953.

The force-time diagram is obtained for a prescribed discontinuity in the transverse velocity of an infinite flat plate moving through a compressible inviscid fluid. Conversely, the velocity and acceleration time histories are obtained when a known force is suddenly applied to the plate.

The calculations are made on the basis of the acoustic approximation and the results are directly applicable in the field of acoustics. A. R. Mitchell, Scotland

190. **Roy, M., On the fluid resistance of ideal compressible flow** (in French), *Aerotecnica* **33,** 1, 110–113, Feb. 1953.

The author re-examines the question of wave drag on a symmetrical body in a steady, uniform flow. He proposes the following hypotheses: (1) Streamlines extend to infinity in both directions along the x-axis; (2) in all planes transverse to the x-axis, velocity and pressure increments caused by the body diminish more rapidly than $1/(y^2 + z^2)$; (3) at great distance downstream, the acceleration of the final velocity distribution tends asymptotically to zero. With the additional help of the integral momentum theorem, Bernoulli's law for adiabatic flow, its conservation across shock waves, and the expression for entropy change of a perfect gas, he derives a relation for the drag force on the body. If no entropy change takes place along any streamline the drag vanishes; thus, for drag to be present, it appears that the flow must be supersonic somewhere over the object and a shock wave must exist. An entropy-enthalpy diagram is presented on which the various quantities in the analysis are shown. These are discussed in connection with finding the power used in overcoming drag. While the paper brings out the interesting relation between drag and existence of a shock wave, the argument is sometimes not clear. The author asserts on the basis of hypothesis (3) that the final pressure must equal the initial. Reviewer found it necessary to use (3) and (2) together or add to (3) the requirement that the integral of pressure force over the transverse plane at infinity remain finite.

F. D. Bennett, USA

191. **Hurley, D. G., The pressure on the surface of a flat elliptic cone set symmetrically in a supersonic stream,** *Aero. Res. Counc. Lond. curr. Pap.* **109,** 11 pp., 6 figs., Nov. 1951, published 1953.

Squire [AMR **5,** Rev. 3156] calculated the pressure on a thin elliptic cone, elliptic hypercone, and winglike surface with subsonic leading edges by linear theory and added leading-edge force correction as shown by Jones [AMR **4,** Rev. 1227]. Author amends Squire's calculation for elliptic cone, substituting for leading-edge force correction the evaluation of pressure caused by addition of line sources along the foci of elliptic sections. Boundary conditions on the surface are satisfied on the edges and central section only.

Results obtained by Squire from linear theory are used, but pressure coefficient c_p is calculated from exact relation (depending on Mach number, velocity of flow, and ratio of specific heats).

The drag coefficient c_D, evaluated for a 10% thick body, is stated to be in good agreement with the value obtained from linear theory as used by Squire.

Author's calculations do not replace Squire's mentioned results as they do not deal with a winglike surface. There are some obvious misprints. E. Krahn, England

192. **Johnston, G. W., An investigation of the flow about cones and wedges at and beyond the critical angle,** *J. aero. Sci.* **20,** 6, 378–382, June 1953.

See AMR **6,** Rev. 3481.

193. **Trilling, L., and Walker, Jr., K., On the transonic flow past a finite wedge,** *J. Math. Phys.* **32,** 1, 72–79, Apr. 1953.

Refinement of work by Cole [AMR **4,** Rev. 4527]. Important question of the influence of the shock which terminates the supersonic region remains unsettled. Moreover, Fig. 3 suggests an error in the numerical work. K. G. Guderley, USA

194. **Gruschwitz, E., Remarks concerning a danger produced by control-surface deflections in the near sonic range** (in German), *ZAMP* **4,** 3, 219–221, 1953.

The efficiency of a control surface ($\partial c_L/\partial \beta$) often drops very abruptly in the higher subsonic speed range. For instance, a large elevator angle produced with the aid of a servo device does not much change the stabilizer lift force. If, still at this control setting, a small decrease of the Mach number occurs by reason of a brake operation or a pull-out, the resultant lift force increases very abruptly and can reach values far beyond the ultimate stress limit. A similar increase will happen with a deflected control surface through sudden changes of angle of incidence produced by

a gust or a pull-out. Author believes that accidents of high-speed airplanes may have been caused by these effects, which are typical for profiles with deflected controls. As the lift efficiency $\partial c_L/\partial \alpha$ drops far less abruptly in the transonic range than the control efficiency, the use of an "all movable" or "flying tail" is suggested. Reviewer believes that the heavy wing dropping reported for the high-speed range is also caused by the influence of the angle of incidence upon the aileron efficiency.

H. L. Studer, Switzerland

195. **Chen, Y.-W., Flows through nozzles and related problems of cylindrical and spherical waves,** *Comm. pure appl. Math.* **6,** 2, 179–229, May 1953.

The axisymmetric flow in the neighborhood of the leading Mach line $C-$ and its reflection $C+$ on and close to the axis is considered, when a first-order discontinuity in velocity exists at the intersection D of the two waves on the axis. At $D(x_0, 0)$, $\theta = 0$, $\beta = \beta_0 + O(x_0 - x)^\gamma$ for $x_0 > x$ and $\theta = 0$, $\beta = \beta_0 + O(x - x_0)^{\gamma'}$ for $x > x_0$ where $\beta = \arctan (M^2 - 1)^{1/2}$. When γ and $\gamma' > 1/2$, the flow is continuous in the neighborhood of D, and the first derivatives of θ and β with respect to x and y are continuous in crossing $C-$ and $C+$.

When $\gamma > 1/2$, $\gamma' = 1/2$ and, for $x > x_0$, $\beta = \beta_0 + B(x - x_0)^{1/2} + O(x - x_0)^{\gamma''}$ with $\gamma'' > 1/2$, the first derivatives of θ and β with respect to x and y have jump discontinuities. The streamline curvature upstream of $C-$ is $O(y^{\gamma-1})$, $O(y^{-1/2})$ downstream and has the same sign as B. For a compression $B < 0$, the continuous flow breaks down in the neighborhood of $C+$ and limit lines are formed. For an expansion $B > 0$, the flow is continuous near D. Although linearized theory proves that the discontinuity on $C-$ is reflected at D as a logarithmic singularity on $C+$, the exact inviscid theory shows that the first derivatives of θ and β with respect to x and y remain finite and are continuous in crossing $C+$ from either side. They are $O(y^{-1})$ near D.

It is shown that problems in unsteady cylindrical and spherical wave motion may be treated similarly.

G. M. Lilley, England

196. **Li, T.-Y., and Nagamatsu, H. T., Shock-wave effects on the laminar skin friction of an insulated flat plate at hypersonic speeds,** *J. aero. Sci.* **20,** 5, 345–355, May 1953.

An approximate theory on the phenomena of interaction between the shock wave and the laminar boundary layer on an insulated flat plate at hypersonic speeds has been formulated. Results on the rate of growth of the boundary-layer thickness and the rate of decay of the shock-wave strength have been found that hold for $M^{2(2+\omega)}R^{-1} = 0(1)$. A new set of formulas for the average skin-friction coefficient C_F over an insulated flat plate at hypersonic speeds has been obtained. Contrary to the conventional theory that predicts a steady decrease in C_F as M increases, the present results indicate that C_F may increase with M at hypersonic Mach numbers.

From authors' summary by T. Gullstrand, Sweden

197. **Hasimoto, Z., A note on cross Mach lines in simple waves in the plane supersonic flow,** *J. phys. Soc. Japan* **8,** 2, 248–251, Mar.-Apr. 1953.

Explicit representation of cross Mach lines in simple waves has already been obtained for the case of polytropic gases. In the present paper, a more general expression is deduced without restriction to any special type of gases. It is also shown that the distribution of the stream function along a cross Mach line can be expressed in a very simple form.

From author's summary by J. F. Manildi, USA

198. **Hasimoto, Z., On the limiting line in a simple wave,** *J. phys. Soc. Japan* **8,** 2, 251–254, Mar.-Apr. 1953.

Discussion centers on the condition in the neighborhood of an envelope formed by the straight Mach lines in a simple wave, obtaining the result that at the envelope, which may be called a "limiting line" as in the case of ordinary flows other than simple waves, the cross Mach lines have a cusp and the distribution of the stream function along the cross Mach lines takes an extremum.

From author's summary by J. F. Manildi, USA

199. **Tamada, K., On the detachment of shock wave from the leading edge of a finite wedge,** *J. phys. Soc. Japan* **8,** 2, 242–247, Mar.-Apr. 1953.

The transonic flow over a wedge with an attached shock is computed approximately, considering the flow to be a small perturbation of a uniform flow. A comparison of these approximate results with a solution of the boundary-value problem in the hodograph (computed recently by the reviewer) shows sufficient disagreement to indicate that the above approximations are unsatisfactory.

H. Yoshihara, USA

200. **Borg, S. F., Approximate solutions for the detached shock problem,** *J. aero. Sci.* **20,** 2, 137–138, Feb. 1953.

Note in Readers' Forum.

201. **Cabannes, H., Contribution to the theory of compressible fluids. Transonic flow. Shock waves** (in French), *Ann. sci. École norm. sup.* (3) **69,** 1, 1–63, Jan.-Mar. 1952.

Following preliminaries dealing with the equations of gas dynamics, author proposes a compressibility law which, when employed in considerations of continuous transonic flows, results in a generalization that includes known solutions as special cases. He examines further the position and shape of shocks, given the form of a body placed in a stream of known velocity.

M. J. Goglia, USA

202. **Jenkins, R., and Aronofsky, J. S., Unsteady radial flow of gas through porous media,** *J. appl. Mech.* **20,** 2, 210–214, June 1953.

See AMR **6,** Rev. 2844.

203. **Green, L., Jr., and Wilts, C. H., Nonsteady flow of gas through a porous wall,** Proc. First. U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 777–781, 1952.

The temporal variation of pressure distribution consequent to the application of a sudden pressure difference across the wall is governed by a nonlinear diffusion equation in which the diffusivity is proportional to the pressure. Solutions of the approximating finite-difference equations for imposed pressure ratios of 2 and 10 are found by iterative adjustment of the mesh reactances of an electrical network analog.

A. F. Pillow, Australia

Turbulence, Boundary Layer, etc.

(See also Revs. 178, 281, 283, 308, 326, 350, 356, 360)

204. **Lin, C. C., A critical discussion of similarity concepts in isotropic turbulence,** "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 19–27, 1953.

Author discusses the question of the extent of the self-preservation of the energy spectrum function in the process of decay of homogeneous isotropic turbulence. Physical arguments are adduced to explain the experimental result that considerable

deviation from similarity is observed among the low frequency components of the motion. Adopting Heisenberg's formula for the transfer function, author analyzes the stability of the quasi-equilibrium spectrum to a small perturbation. Results of the calculation afford theoretical evidence for the hypothesis that the large energy-containing eddies are slow to adjust to the condition of quasi-equilibrium. L. M. Grossman, USA

205. **Burgers, J. M., Some considerations on turbulent flow with shear, Parts I, II,** *Proc. k. Ned. Akad. Wet. (B)*, **56,** 2, 125–147, Mar./Apr. 1953.

This is a highly intuitive attempt to express turbulent shear stress in terms of functions resembling turbulent energy spectrum and Lagrangian autocorrelation function. The author starts with a set of ad hoc linear quasi-Navier-Stokes equations in Lagrangian form and with a number of empirical constants. After integrating, he obtains experimental orders of magnitude by a number of postulates and adjustment of constants.

Reviewer remarks that the principal general result [Eq. 18] has plausible appearance but may be no more nearly correct than, e.g., that which would follow from a (much simpler) mixing-length "theory" with Lagrangian scale in place of mixing length; however, this paper may have good heuristic value.

S. Corrsin, USA

206. **Frenkiel, F. N., Turbulent diffusion: Mean concentration distribution in a flow field of homogeneous turbulence,** Advances in appl. Mech. **III,** 61–107, 1953. $9. [Academic Press, Inc., N. Y.]

Problem of turbulent diffusion, so important from a practical standpoint, is treated by author from a more rigorous point of view. After elementary discussion on fundamentals of statistical concepts of homogeneous, isotropic, and stationary turbulence, of spectra, and local isotropy, author derives fundamental equations of turbulent diffusion, illustrated by some examples. The problems subsequently discussed are mean concentration distribution produced by a point source of diffusion and by an infinite line source of diffusion. In each case author solves the following subcases: Large and small distances from a source, and approximate solutions. In the final section, author compares Fick's law (1855) of molecular diffusion and statistical theory of turbulence. Interesting relations for apparent coefficient of eddy diffusion, etc., are found. Mathematics used is simple and paper is very understandable. Some statements on the relation between the kinetic theory of gases and turbulence may be subject to slight criticism, but, in general, paper presents a contribution to the theory of diffusion. M. Z. Krzywoblocki, USA

207. **Obukhoff, A. M., and Yaglom, A. M., The microstructure of turbulent flow,** *NACA TM* 1350, 41 pp., June 1953.

See AMR **4,** Rev. 3013.

208. **Laufer, J., The structure of turbulence in fully developed pipe flow,** *NACA TN* 2954, 53 pp., June 1953.

Measurements, principally with a hot-wire anemometer, were made in fully developed turbulent flow in a 10-in. pipe at speeds of approximately 10 and 100 fps. Emphasis was placed on turbulence and conditions near the wall. The results include relevant mean and statistical quantities. such as Reynolds stresses, triple correlations, turbulent dissipation, and energy spectra. It is shown that rates of turbulent-energy production, dissipation, and diffusion have sharp maxima near the edge of the laminar sublayer and that there exists a strong movement of kinetic energy away from this point and an equally strong movement of pressure energy toward it. Finally it is suggested that, from the standpoint of turbulent structure, the field may be divided into three regions: (1) Wall proximity where turbulence production, diffusion, and viscous action are all of about equal importance; (2) the central region of the pipe where energy diffusion plays the predominant role; and (3) the region between (1) and (2) where the local rate of change of turbulent-energy production dominates the energy received by diffusive action.

Reviewer finds this a valuable addition to our knowledge of turbulent shear flows. It supplements the author's two-dimensional channel study [AMR **4,** Revs. 345, 346], particularly in the laminar sublayer.

From author's summary by J. M. Robertson, USA

209. **Chapman, D. R., and Kester, R. H., Measurements of turbulent skin friction on cylinders in axial flow at subsonic and supersonic velocities,** *J. aero. Sci.* **20,** 7, 441–448, July 1953.

Paper is an important contribution to the rapidly increasing body of technical literature on turbulent boundary layers for a wide range of Mach numbers, both subsonic and supersonic. Present experimental work covers range from 0.5 to 3.6 and Reynolds numbers from 4×10^6 to 32×10^6.

A thorough and systematic review of other work on the problem is first presented with a discussion of important applications such as skin-friction drag and heat-transfer calculations. The experimental work on which the present paper is based is then described. This covers fore-drag measurements on cones and cone-cylinder combinations, with provisions made to eliminate the effects of base drag. Suitable tripper rings were installed at the nose of the cones to insure a turbulent boundary layer. Some limited study was also made on the effects of pressure variations along the body and these were found to introduce no major effects on skin friction.

The primary results of the tests are the turbulent skin-friction coefficients for the ranges of Mach and Reynolds numbers already mentioned. These data are obtained from cylinders ranging in length-diameter ratio from 8 to 23. A comparison with other results, including local shear force measurements as well as momentum surveys, discloses a small discrepancy between the two, the former being about 5% lower than the latter. This discrepancy has been found in similar studies made at The University of Texas by a research group under the reviewer's supervision.

M. J. Thompson, USA

210. **Richardson, L. F., Transforms for the eddy-diffusion of clusters,** *Proc. roy. Soc. Lond. (A)* **214,** 1116, 1–20, Aug. 1952.

Diffusion of particulate matter in a turbulent fluid medium is difficult to predict or describe mathematically, partly because the speed with which any two particles will move away from each other is a function of the distance between the particles. In 1926, Richardson [*Proc. roy. Soc. Lond. (A)* **110,** 709–737] took this into account in a novel treatment which dealt with the way in which particles were distributed with regard to each other rather than with the "average concentration." In the present paper he enlarges on this idea and offers methods of checking his theoretical results. The method of solution of a given problem is to use a known distribution of particulate matter to find a corresponding "distance-neighbor function" which is a transform of the known distribution. The behavior of this transform as a function of time can then be predicted, its nature at some subsequent time arrived at, and from this, by a reverse transformation, the corresponding distribution of particulate matter can be calculated. The advantage of this treatment is claimed to be that the distance-neighbor function behaves in a more uniform and predictable fashion than the concentration itself.

Reviewer believes the ideas of Richardson will benefit research

into the nature of turbulent diffusion, but no immediate engineering application is seen. The mathematical detail is great and the author has so far limited himself to a one-dimensional problem, although he realizes the atmospheric problem is three-dimensional. F. I. Badgley, USA

211. Tani, I., and Hama, F. R., Some experiments on the effect of a single roughness element on boundary-layer transition, *J. aero. Sci.* **20,** 4, 289–290, Apr. 1953.

A wire is stretched across a plate in an air flow. The position of the transition is observed as a function of the position of the wire and free-stream velocity. A theoretical parameter is introduced, by analogy with Taylor's work on separation, and the data agree with a constant value of this transition parameter. Similar experiments in water are reported and they reveal that the tripping element creates vortexes which build up before collapsing in random motion. R. Betchov, USA

212. Wuest, W., Approximate calculation and stability behavior of laminar boundary layer with suction through single slot (in German), *Ing.-Arch.* **21,** 2, 90–103, 1953.

Author gives approximate computation of development of laminar boundary layer along a flat plate with suction slots. Stability of the laminar flow with the resulting velocity distributions is computed by the Tollmien method. Purpose is to compare stabilization obtained with slots with that for continuous suction.

Author concludes that critical Reynolds number cannot be increased very much by series of slots except for small velocity and large boundary-layer thickness.

Author notes the several assumptions made, including use of one-parameter family of velocity distributions, neglect of sink pressure field of slots, and application of Tollmien theory to periodic variation of boundary layer. H. L. Dryden, USA

213. Illingworth, C. R., The laminar boundary layer of a rotating body of revolution, *Phil. Mag.* (7) **44,** 351, 389–403, Apr. 1953.

Article is a contribution to boundary-layer theory. Author establishes correlation between compressible flow around spinning body of revolution with uniform main stream of Prandtl number 1 and viscosity proportional to absolute temperature, with solution of slightly modified equations of incompressible plane flow, utilizing von Mises and Mangler transformations. Equations are applied to boundary layer of spinning cone, since cone has uniform main stream. Approximations are developed for ballistic case of "slow" rotation. Case of nonuniform main stream also is discussed. H. L. Dryden, USA

214. Murphy, J. S., Some effects of surface curvature on laminar boundary-layer flow, *J. aero. Sci.* **20,** 5, 338–344, May 1953.

The order-of-magnitude analysis as introduced by L. Prandtl to simplify Navier-Stokes equations into the "boundary-layer" form is extended for two-dimensional flow to the cases that (a) the ratio K' of curvature K of surface to the reference length L is of the order one, but the derivative of dimensionless curvature K' toward the dimensionless coordinate x' measured along the surface ($x' = x/L$) is of the order $1/\delta'$ (δ' dimensionless boundary layer thickness $= \delta/L$); (b) that K' and $\partial K'/\partial x'$ are both of order $1/\delta'$. Boundary-layer equations resulting from assumption (b) are solved for a surface of curvature $K = A\,(U_1/\nu)^{1/2}x^{-1/2}$ (A constant, U_1 velocity of potential flow along surface assumed constant, ν viscosity, x coordinate measured along surface). Solution is for $A = 0$, identical with Blasius solution for the flat plate. It indicates that on a convex surface the wall shearing stress is larger and on a concave surface smaller than on a flat plate. Curvature also influences the shape of the velocity profiles, especially near the outer border of the boundary layer. E. R. G. Eckert, USA

215. Cooper, R. D., and Tulin, M. P., The laminar flow about very slender cylinders in axial motion, including the effect of pressure gradients and unsteady motions, *David W. Taylor Mod. Basin Rep.* 838, 21 pp., Apr. 1953.

Purpose of investigation is to estimate effect of transverse curvature on incompressible boundary layer in cases for which boundary-layer thickness is not small relative to radius of transverse curvature. Equation of motion is linearized in a rather arbitrary manner justified to a certain degree in some cases. If solutions of simplified equation are meaningful approximate solutions in the cases studied, authors' conclusions are: (1) For a cylinder in steady axial motion with no external pressure gradient, as well as with favorable or adverse pressure gradient of Falkner-Skan type, wall shear stress is always increased by transverse curvature. (2) For the case of arbitrary unsteady axial motion of cylinder initially at rest, a general solution of linearized equation is obtained. In case of impulsive start, flow field is divided into two regimes, one independent of time, the other independent of axial spatial variable. Authors also show that exact solutions for "similar" velocity profiles exist in special case. H. Görtler, Germany

216. Wegener, P. P., Winkler, Eva M., and Sibulkin, M., A measurement of turbulent boundary-layer profiles and heat-transfer coefficient at $M = 7$, *J. aero. Sci.* **20,** 3, 221–222, Mar. 1953.

The turbulent boundary-layer velocity and stagnation enthalpy profiles on the wall of the NOL hypersonic wind tunnel at Mach number 7 have been measured. The wall temperature was approximately 60% of stagnation and was kept constant. The static pressure at the wall was found to be equal to the static pressure in the main stream outside of the boundary layer. The velocity profile was found to be in good agreement with the usual 1/7 power law. The average rate of heat transfer was measured two ways—from the energy deficiency which is given by the velocity and total temperature profiles, and from the temperature gradient in the wind-tunnel wall at various stations. The two measurements were in good agreement. The velocity profile was also compared in terms of the log law with the incompressible and with van Driest's compressible theory. The agreement again was found to be fairly good. P. A. Libby, USA

217. Nonweiler, T., The two-dimensional laminar boundary layer at hypersonic speeds, *Coll. Aero. Cranfield Rep.* **67, 37** pp., 4 figs., Jan. 1953.

Author treats the two-dimensional laminar boundary layer at hypersonic speeds in the absence of a pressure gradient and points out that flow is not over a flat plate unless Reynolds number R is of order of ninth power of Mach number M. Effect of surface slip is shown to be negligible for the cases considered.

Appropriate account is taken of the variation of specific heat, Prandtl number, and viscosity with temperature. Coefficients of skin friction, heat transfer, and profiles of velocity and temperature are worked out. The thickness of the boundary layer is shown to increase as $(M^3/R)^{1/2}$ at high Mach number, and the form of the boundary corresponding to uniform pressure is worked out. Some remarks are made on the stability of the laminar layer and its transition to turbulence. C. C. Lin, USA

218. **Drougge, G., An experimental investigation of the influence of strong adverse pressure gradients on turbulent boundary layers at supersonic speeds,** *Flygtekn. Försöksanst. Medd.* no. 46, 22 pp., 1953.

The investigation deals with the influence upon turbulent boundary layer of a shock wave originating at a concave corner. Appreciable separation effects were found when the strength of the shock wave was increased by increasing the corner angle up to 20°. From author's summary by A. Petroff, USA

219. **Thomas, T. Y., The separation of supersonic flow from curved profiles,** *Indiana Univ. Publ., Sci. Ser.* no. 17, 69 pp., 1951. $1.50.

Four assumptions concerning nature of supersonic flow surrounding laminar boundary layer separated from curved two-dimensional airfoil are stated. These form basis for simple utilization of well-known shock-expansion theory to calculate for two Guidonia profiles the final pressure in separated region, the point of separation, and the back pressure interval over which pressure increases abruptly. Results are in reasonable agreement with Ferri experiments. Doubt is expressed by author that basic assumptions are valid for other than Guidonia class of profiles. Paper is written in great detail, with half of space devoted to review of two-dimensional characteristics theory.

J. S. Isenberg, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 17, 194, 250, 251, 254, 281, 324, 327)

220. **Morley, A. W., Aircraft propulsion. Theory and performance,** London, New York, Toronto; Longmans, Green & Co., 1953, viii + 221 pp. $5.50.

Almost all books on aircraft propulsion, whether they are introductory or advanced, try to fulfill three aims: They attempt to cater to the needs of the designer in the industry, those of the research worker, and those of the student. Naturally, they cannot do this within the limitations of one volume and, therefore, fall short of all three aims. Morley's book is written for the student and is a valuable contribution to the art. Its ten chapters—The thrust required for flight, Basic thermodynamics, Introductory gas dynamics, The turbojet engine, Gas-turbine cycle calculations, The propeller turbine and compound gas turbine, Axial-flow theory, The piston-type aero-engine, The ramjet engine, and The rocket motor—are well organized and contain much of the information needed for the student who meets the subject for the first time. The volume contains a valuable bibliography and also altitude tables. However, the book has some serious shortcomings which will make its use, particularly in the United States, difficult.

Performance calculations in the United States seem to differ from that presented in the book. In particular, the reduction of the parameters to flight speeds of 100 fps limits usefulness when compressibility effects are significant. Reviewer feels that insufficient emphasis is placed on warning the student that the performance formulas are valid for low flight speeds only and have to be corrected when flight speeds above approximately 0.5 Mach number are involved. Although it is pointed out that C_{D0} will reach a maximum and then decrease, the graph presenting these values is not carried out far enough to show either a maximum or values past this maximum. It is unfortunate nomenclature to use "nondimensional" thrust expressions which have dimensions of ft² or to give temperatures in °K and in ft²/sec². Such practice will confuse experienced engineers, let alone beginners in the field. Several statements in comparing piston-engine-driven aircraft with that of turbojet power are insufficiently documented. Also, use of K and k as constants with several meanings in different parts of the chapter will lead to unnecessary confusion. In this country, Oswald's efficiency factor is used in the expression of the drag coefficient, but a not well-defined constant K is used by the author. Difficulties also arise from use of the same letter to denote different concepts (to quote only one in a short review of this kind, F is used for thrust and for frictional losses).

Reviewer has found in the various courses he taught in aircraft propulsion that the cycle concept is confusing to the student when applied to jet type power plants. A flow concept with heat addition is the only way to introduce the theory of jet engines. However, Morley is not alone in making this mistake. The student will get the impression that there is only one way to calculate axial-flow turbomachines, i.e., by means of velocity diagrams. Although this method is useful for the first evaluation of such machines, both the direct and indirect methods of analyses yield more accurate results but are not even mentioned in the book. Also, no mention is made of radial- or mixed-flow turbomachine theory. The last two chapters on ramjets and rockets would need considerable addition of material. T. P. Torda, USA

221. **Seiler, A., A new graphical method for preliminary calculations concerning airplane performance** (in French), *Bull. tech. Suisse Rom.* **79,** 9–10, 135–140, May 1953.

With the goal of simplifying airplane performance calculations, as, for instance, climb and range as well as minimum vertical velocity, author suggests a new graphical method. The maximum value of C_L^3/C_D^2 used in the classical equations can be graphically determined by an auxilliary curve in the polar diagram which is mathematically defined and is a constant for a certain scale of the polar scale. Method has practical value only for routine calculations in the incompressible range. H. Studer, Switzerland

222. **Brown, B. P., Chilton, R. G., and Whitten, J. B., Flight investigation of a mechanical feel device in an irreversible elevator control system of a large airplane,** *NACA Rep.* 1101, 14 pp., 1952.

Supersedes article reviewed in AMR **5,** Rev. 2131.

223. **Rogallo, V. L., and McCloud, III, J. L., Surveys of the flow fields at the propeller planes of six 40° sweptback wing-fuselage-nacelle combinations,** *NACA TN* 2957, 57 pp., June 1953.

The flow fields at the propeller planes of six 40° sweptback semi-span wing-fuselage-nacelle combinations were surveyed to provide data to enable the study of the characteristics of the flow fields and their effect on propeller-oscillating aerodynamic loads. The results of the surveys are presented in the form of angles that define the direction of the local velocity relative to the survey disk and as the ratios of the local velocities to free-stream velocity. These parameters are shown as functions of the angular position around the survey disk for given radial positions. Typical propeller-oscillating air loads, computed by the method of *NACA TN* 2192 using measured flow-field data, are presented to demonstrate the significance of the flow parameters. Also shown are comparisons of measured and predicted upflow angles for all models at a specific angle of attack.

The results of the surveys show that variations of the flow parameters with angular position are predominantly first-order sinusoidal for the six models tested and, thus, are similar to results for unswept-wing airplane reported in *TN* 2192 [AMR 4, Rev. 3029].

The rotational flow angle is the major contributor to the oscillating aerodynamic loads and has its maximum and minimum

values at the horizontal center line of the propeller disk, where its value is determined by the upflow angle.

The upflow angles predicted by methods of *TN* 2795, 2894 [AMR 6, Revs. 1018, 3834] were found to be in good agreement with measured angles. From authors' summary

224. Legendre, R., Laminar profile of airfoil for subsonic velocity (in French), *Rech. aéro.* no. 33, 9–10, 1953.

225. Miles, J. W., A general solution for the rectangular airfoil in supersonic flow, *Quart. appl. Math.* **11,** 1, 1–8, Apr. 1953.

A solution is presented for the potential on a rectangular wing that makes arbitrary (but small) deviations from a reference plane. The analysis is based on the four-dimensional wave equation and an application of the solution would require four integrations of the given function. The result is less general (being restricted to the plane of the wing) than that derived by Gardner [AMR **4,** Rev. 2124] using a different method.

H. Lomax, USA

226. Nickel, K., On specific airfoil systems (in German), *Ing.-Arch.* **20,** 6, 360–376, 1952.

Author extends the lifting-line theory of Betz and the thin-airfoil theory of Birnbaum to apply, respectively, to a system of lifting lines with a common axis and a system of airfoils with parallel generators. In place of the original integral equations determining the circulation and vortex distributions along the respective single lines, linear systems of such equations now arise. Solutions of these in closed form are obtained in each case and, as examples, the fields disturbed by a pair of lifting lines and a pair of airfoils in tandem are computed. Maurice Holt, England

227. Fischel, J., Naeseth, R. L., Hagerman, J. R., and O'Hare, W. M., Effect of aspect ratio on the low-speed lateral control characteristics of untapered low-aspect-ratio wing equipped with flap and with retractable ailerons, *NACA Rep.* 1091, 47 pp., 1952.

Supersedes articles reviewed in AMR **4,** Revs. 3650, 3664.

228. Speilberg, I. N., The two-dimensional incompressible aerodynamic coefficients for oscillatory changes in airfoil camber, *J. aero. Sci.* **20,** 6, 432–434, June 1953.

Note in Readers' Forum.

229. Lomax, H., and Sluder, L., Chordwise and compressibility corrections to slender-wing theory, *NACA Rep.* 1105, 19 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 2596.

230. Welsh, C. J., The drag of finite-length cylinders determined from flight tests at high Reynolds numbers for a Mach number range from 0.5 to 1.3, *NACA TN* 2941, 12 pp., June 1953.

Drag coefficients were determined for cylinders with fineness ratios of 15, 30, and 60 for a Mach number range from 0.5 to 1.3. The test cylinders were mounted on a test body and were propelled by a two-stage rocket arrangement. Test data were obtained using the Doppler radar technique, and the author estimated a very high order of accuracy.

C_D increased from approximately unity at $M = 0.5$ to around 1.8 at $M = 0.95$, thereafter decreasing to about 1.5 at $M = 1.3$. C_D was found to increase with fineness ratio for the lower Mach numbers but appeared to be little affected by fineness ratio at supersonic speeds. G. N. Cox, USA

231. Gowen, F. E., and Perkins, E. W., Drag of circular cylinders for a wide range of Reynolds numbers and Mach numbers, *NACA TN* 2960, 26 pp., June 1953.

Pressure distributions around circular cylinders placed perpendicular to the stream for subsonic and supersonic flow conditions have been obtained. Drag coefficients calculated from these wind-tunnel tests and from transonic free-flight tests are presented.

Drag data are presented for the Mach number range of 0.3 to 2.9. The Reynolds numbers for the subsonic and supersonic Mach numbers were within the ranges of approximately 50,000 to 160,000 and 100,000 to 1,000,000, respectively. No effects of Reynolds number were found for flow in the supersonic Mach number range of the tests. The drag coefficient increased with increasing Mach number to a maximum of approximately 2.1 at a Mach number of unity. In the supersonic Mach number range, the drag coefficient decreased with increasing Mach number to a value of about 1.34 at a Mach number of 2.9. Drag data from other investigations have been included for comparison.

The effects of fineness ratio on drag at supersonic Mach numbers were also investigated and found to be small.

From authors' summary

232. Finn, R. K., Determination of the drag on a cylinder at low Reynolds numbers, *J. appl. Phys.* **24,** 6, 771–773, June 1953.

Drag coefficients for a cylinder were measured at Reynolds numbers from 0.06 to 6.0 by observing the deflections of thin wires suspended in an air stream. The results confirm a theoretical equation proposed by Lamb and are consistent with experimental data of other investigators.

From author's summary

233. Young, A. D., The calculation of the profile drag of aerofoils and bodies of revolution at supersonic speeds, *Coll. Aero. Cranfield Rep.* no. 73, 30 pp., Apr. 1953.

Comprehensive methods are developed and discussed for calculation of the boundary layers in the laminar and turbulent states and for the interaction of boundary layers and main stream away from the neighborhood of shock waves. The problem of the effects of shock-wave boundary-layer interaction is discussed in the light of existing experimental data. Author believes that more systematic data are required before quantitative prediction of the interaction effects in any particular case can be confidently made. For many practical cases of interest these latter effects are small.

Detailed results of calculations will be given in a subsequent report. From author's summary by F. Keune, Sweden

234. Beane, Beverly, Drag reduction due to wing incidence and twist for wing-body combinations, *Douglas Aircr. Co. Rep.* SM-14740, 18 pp., Mar. 1953.

For fixed lift, the optimum wing-body combination in supersonic flow is computed by the method of E. W. Graham [AMR **6,** 1974]. Delta wings with sonic leading edges are combined with circular bodies of various span-to-diameter ratios. The results show that the optimum wing incidence is negative relative to the body axis, resulting in minimum drag. Maximum drag reduction for zero incidence is obtained for a span-to-diameter ratio of about 2. The amount of the reduction is between 5 and 20% and is very sensitive to the magnitude of the computed body force. Therefore, author suggests intensive studies of viscous and nonlinear effects for wing-body interference problems. Also, a geometric twist of the wing is required and gives a small additional drag reduction. N. Scholz, Germany

235. **Gray, V. H., and von Glahn, U. H., Effect of ice and frost formations on drag of NACA 65_1-212 airfoil for various modes of thermal ice protection,** *NACA TN* 2962, 68 pp., June 1953.

The effects of primary and runback icing and frost formations on the drag of an 8-ft-chord NACA 65_1-212 airfoil section were investigated over a range of angles of attack from 2° to 8° and airspeeds up to 260 mph for icing conditions, with liquid-water contents ranging from 0.25 to 1.4 gram per cu meter and datum air temperatures of −30 to 30 F.

The results showed that glaze-ice formations, either primary or runback, on the upper surface near the leading edge of the airfoil caused large and rapid increases in drag, especially at datum air temperatures approaching 32 F and in the presence of high rates of water catch. Ice formations at lower temperatures (rime ice) did not appreciably increase the drag coefficient over the initial (standard roughness) drag coefficient. Cyclic deicing of the primary ice formations on the airfoil leading-edge section permitted the drag coefficient to return almost to the bare airfoil drag value. Runback icing on the lower surface did not present a serious drag problem except when heavy spanwise ridges of runback ice occurred aft of the heatable area. Frost formations caused rapid and large increases in drag with incipient stalling of the airfoil.

From authors' summary

236. **Cohen, Doris, and Friedman, M. D., Theoretical investigation of the supersonic lift and drag of thin, sweptback wings with increased sweep near the root,** *NACA TN* 2959, 51 pp., June 1953.

Linearized theory is applied to thin flat sweptback wings with discontinuity in leading edge, sweepback of inboard part being higher than that of outboard part. Pressure distribution is calculated, starting from known results for triangular wing with sweepback of inboard part, adding outboard part by superposition of conical flelds with center in discontinuity, thus canceling downwash of first wing on the outer panels. Analytical expressions in elliptic integrals for pressure distribution are given. A cutoff of wing tips is considered, using Mirel's cancellation technique. Numerical values are given for two wings at different Mach numbers. Aerodynamic center location is calculated. Total lift and drag are calculated separately by conical field methods.

Results show that, in absence of viscosity, over-all effects of cranked-wing characteristics show no striking influence of concentration of sweep near root, compared with triangular wing with same sweepback as cranked-wing outer panels. Lift is abruptly reduced ahead of region within overlapping Mach cones from bends in leading edge. R. Timman, Holland

237. **Martina, A. P., Method for calculating the rolling and yawing moments due to rolling for unswept wings with or without flaps or ailerons by use of nonlinear section lift data,** *NACA TN* 2937, 41 pp., June 1953.

Report demonstrates by numerical examples how methods developed in *NACA Reps.* 865 and 1090 may be applied to calculation of rolling and yawing moments due to rolling above the linear portion of the lift curve. If there are no large discontinuities in either the lift curve or the twist of the wing (including discontinuities produced by flaps or ailerons), the method may be used beyond the angle of maximum lift, otherwise it may be used up to this point.

Method is based on lifting-line theory. Report is supplementary to the two cited references, which contain theory. Partial check of computations against experiment for a particular case (wing-along computations vs. wing-body model experiments) up to about 16° angle of attack reveal good agreement of theory with experiment. H. K. Weiss, USA

238. **Lomax, H., Lift developed on unrestrained rectangular wings entering gusts at subsonic and supersonic speeds,** *NACA TN* 2925, 44 pp., Apr. 1953.

Paper presents an estimate, based on theoretical calculations, of the forces induced on a wing that is flying at a constant forward speed and suddenly enters a vertical gust. New results for a two-dimensional restrained wing entering a sharp-edged gust at Mach numbers 1.0, 0.8, and 0.5 are given. These, together with previously published theoretical results, are used to estimate the effect of wing aspect ratio (2 to ∞) and airplane mass on the lift response in the Mach number range from 0 to 2, for both triangular and sharp-edged gusts. Pitching and wing bending are neglected, and only wings of rectangular planform are considered.

Y. C. Fung, USA

239. **Racisz, S. F., Effects of independent variations of Mach number and Reynolds number of the maximum lift coefficients of four NACA 6-series airfoil sections,** *NACA TN* 2824, 32 pp., Nov. 1952.

Lift characteristics were determined for a family of airfoil sections with and without leading-edge roughness over the Mach number range 0.1 to 0.5. The Reynolds number ranged from 1.5×10^6 to 9.0×10^6. It was found that initially abrupt stall of certain sections became more gradual with increasing Mach number. Leading-edge roughness for all cases and Mach number resulted in gradual stalls. Maximum lift, generally unaffected for thin sections, decreased with increasing thickness and Mach number. From author's summary by S. Lampert, USA

240. **Sivells, J. C., and Westrick, Gertrude C., Method for calculating lift distributions for unswept wings with flaps or ailerons by use of nonlinear section lift data,** *NACA Rep.* 1090, 25 pp., 1952.

Supersedes article reviewed in AMR 4, Rev. 3345.

241. **Lomax, H., Heaslet, M. A., Fuller, F. B., and Sluder, L., Two- and three-dimensional unsteady lift problems in high-speed flight,** *NACA Rep.* 1077, 55 pp., 1952.

Supersedes articles reviewed in AMR 4, Revs. 3306, 3952; 5, Rev. 479.

242. **Bethwaite, C. F., and Langley, R. A., Notes on research into some aspects of stall-warning devices,** *Coll. Aero. Cranfield Rep.* 72, 8 pp., 10 figs., Apr. 1953.

The problems of detecting and indicating an approaching stall have been investigated in flight on an Anson aircraft. A lower-surface flap near the leading edge of the wing detects the approaching stall at a speed which depends critically on the length of the flap and on its location, but the margin of warning speed over stalling speed is reasonably independent of landing-flap position and throttle setting. A trailing-edge flap is being developed as a stall detector. A "stick-shaker" is the most acceptable form of stall indicator, and ground tests show that a frequency of shake of about 6 cps is desirable. A practical stick-shaker of this frequency has been satisfactorily flight-tested on the Anson. Further development work is in progress.

From authors' summary

243. **Stone, R. W., Jr., Garner, W. G., and Gale, L. J., Study of motion of model of personal-owner or liaison airplane through the stall and into the incipient spin by means of a free-flight testing technique,** *NACA TN* 2923, 28 pp., Apr. 1953.

Dynamically similar model was catapulted from top of shed, with controls set to cause a spin. Attitude and position were re-

corded by cameras, allowing angles of attack and sideslip and angular and linear velocities to be computed. Equations used in computations are presented. Motion in spin entry appeared repeatable from run to run. Angle of attack approached zero when airplane became inverted during spin entry, implying that recovery could best be made at this point. Test technique appears sound and worth while. G. Bull, USA

244. Weick, F. E., Sevelson, M. S., McClure, J. G., and Flanagan, M. D., Investigation of lateral control near the stall. Flight investigation with a light high-wing monoplane tested with various amounts of washout and various lengths of leading-edge slot, *NACA TN* 2948, 61 pp., May 1953.

Flight tests were made with a light high-wing monoplane to investigate possibilities for obtaining satisfactory lateral control at low flight speeds. The airplane was tested with a plain straight wing, with the wing twisted to various amounts of washout, and with leading-edge slots covering various portions of the span. With each wing configuration the tests were repeated with power on and off and for three center-of-gravity locations. The flow over the wing was observed by means of tufts attached to the upper surface. The results of the tests indicate that reliable control at angles of attack very near the stall can be achieved by the proper use of leading-edge slots and wing washout.

From authors' summary by W. S. Aiken, Jr., USA

245. Pratt, K. G., A revised formula for the calculation of gust loads, *NACA TN* 2964, 15 pp., June 1953.

A revised gust-load formula with a new gust factor is derived to replace the gust-load formula and alleviation factor widely used in gust studies. The revised formula utilizes the same principles and retains the same simple form of the original formula, but provides a more appropriate and acceptable basis for gust-load calculations. The gust factor is calculated on the basis of a one-minus-cosine gust shape and is presented as a function of a mass-ratio parameter in contrast to the ramp gust shape and wing loading, respectively, used for the alleviation factor. The National Advisory Committee for Aeronautics will make use of the revised formula in the evaluation of relevant gust data.

From author's summary

246. Schnitzer, E., and Hathaway, M. E., Estimation of hydrodynamic impact loads and pressure distributions on bodies approximating elliptical cylinders with special reference to water landings of helicopters, *NACA TN* 2889, 31 pp., Apr. 1953.

An approximate method for computing water loads and pressure distributions on lightly loaded elliptical cylinders during oblique water impacts is presented. The method is of special interest for the case of emergency water landings of helicopters. This method makes use of theory developed and checked for landing impacts of seaplanes having bottom cross sections of V and scalloped contours.

An illustrative example is given to show typical results obtained from the use of the proposed method of computation. The accuracy of the approximate method was evaluated through comparison with limited experimental data for two-dimensional drops of a rigid circular cylinder at a trim of 0° and a flight-path angle of 90°. The applicability of the proposed formulas to the design of rigid hulls is indicated by the rough agreement obtained between the computed and experimental results. A detailed computation procedure is included as an appendix.

From authors' summary by C. O. Dohrenwend, USA

247. Reddaway, J. L., Tailplane loads and normal accelerations after an automatic control failure, *Aero. Res. Counc. Lond. curr. Pap.* 111, 35 pp., 1 fig., Dec. 1951, published 1953.

This paper develops information, useful in aircraft design, which takes into account failure in pitch control of an autopilot. Effects evaluated are maximum failures in c.g. normal accelerations, tail-unit accelerations, aerodynamic tail loads, and the time required to reach these maximum values. The following simplified assumptions are made: (a) No change in forward velocity up to the maximum effects; (b) no appreciable effect on lift and pitching moment on the stabilizer produced by elevator changes. Three possible elevator movements are considered: (1) Elevator deflects instantaneously to stop and stays there; (2) elevator deflects instantaneously to nonstop position and further movement owing to response of aircraft does not reach stop; (3) elevator deflects instantaneously to a nonstop position, subsequently reaching and staying at the stop. The derived results are presented in tabular form for these cases, and a specimen calculation is exhibited. The mathematical analysis is clearly and carefully presented in a pair of appendixes and in an addendum covering a reference still in preparation. The author recognizes the need for refinement of this work by going to elevator movement compatible with elevator servo unit and with possible pilot corrective action.

M. G. Scherberg, USA

248. Staff of the Mathematics Division, Tables of complete downwash due to a rectangular vortex, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2461, 18 pp., July 1947, published 1953.

Critical tables are given from which the complete downwash due to a unit rectangular vortex can be read to three places of decimals, on selected lines coplanar with the vortex. These lines are at specified integral multiples of the semi-width of the vortex from the center line of the vortex and are of importance in the solution of wing-loading problems by vortex lattice theory.

From author's summary

249. Bergrun, N. R., An empirically derived basis for calculating the area, rate, and distribution of water-drop impingement on airfoils, *NACA Rep.* 1107, 21 pp., 1952.

See AMR **5**, Rev. 214.

Aeroelasticity (Flutter, Divergence, etc.)

250. Lighthill, M. J., Oscillating airfoils at high Mach number, *J. aero. Sci.* **20**, 6, 402–406, June 1953.

Author studies pressure distribution on an oscillating airfoil at high Mach numbers. Using results of work of Hayes [*Quart. appl. Math.* **5**, 105–106, 1947], the problem reduces to determining the pressure on a moving piston. A cubic expression for the ratio of surface pressure to free-stream pressure is used to obtain a simple formula for the pressure distribution. The pitching moment coefficient due to time rate of change of angle of attack is calculated for a symmetrical airfoil and compared with results obtained by Van Dyke [*NACA TM* 2982] and Wylly [AMR **6**, Rev. 1961]. Results agree with Van Dyke and, with him, show that Wylly's result must be incorrect.

Reviewer considers paper to be a significant contribution.

H. N. Abramson, USA

251. Hirsch, H., The contribution of higher mode resonance to helicopter rotor-blade bending, *J. aero. Sci.* **20**, 6, 407–425, June 1953.

Based on the variable-stiffness blade investigation of the Cornell Aeronautical Laboratory, detailed analysis of experi-

mental dynamic results establishes without doubt the influence of higher bending modes on stresses in blades in flight. While the aerodynamic mechanism of excitation is not yet fully understood, this discovery is of great significance for rotor design, particularly with view to fatigue life of blades. Points requiring urgent clarification are clearly stated.

J. R. M. Radok, Australia

252. **Gossard, M. L., An iterative transformation procedure for numerical solution of flutter and similar characteristic-value problems,** *NACA Rep.* 1073, 45 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 3967.

253. **Runyan, H. L., Single-degree-of-freedom-flutter calculations for a wing in subsonic potential flow and comparison with an experiment,** *NACA Rep.* **1089,** 8 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 4266.

254. **Halfman, R. L., Experimental aerodynamic derivatives of a sinusoidally oscillating airfoil in two-dimensional flow,** *NACA Rep.* 1108, 44 pp., 1952.

Supersedes article reviewed in AMR **5,** Rev. 1848.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 185, 220, 267, 276, 279, 285, 297, 300, 301, 325, 326, 327)

255. **Acharya, Y. V. G., and Janakiram, G., Circulation distribution for six- and eight-bladed propellers,** *Appl. sci. Res. (A)* 3, 6, 410–414, 1953.

The general formulas for determining the circulation function for a finite number of blades, as given by Goldstein, have been evaluated for six- and eight-bladed propellers. The values of Bessel functions necessary for this purpose were computed and are presented in tabulated form.

From authors' summary by A. Petroff, USA

256. **Gruber, J., Design of blade profiles for axial-flow turbomachines** (in German), *Maschinenbau-Technik* **2,** 5, 209–217, May 1953.

A simplification of Theodorsen's "Theory of wing sections of arbitrary shape" [*NACA TR* 411] has been presented by Thwaites [*Aero. Res. Counc. Rep. Mem.* nos. 2166, 2167]. Present paper simplifies Thwaites' method, particularly as to calculation of effect of blade curvature. Simplified method can be used for calculation of velocity and pressure distribution around relatively thin, slightly curved blades of arbitrary section, and for converse problem. Paper includes useful review of fundamental theory.

C. W. Smith, USA

257. **Jarre, G., Axial compressors of high efficiency** (in Italian), Conv. Stud. Propul. Reaz., Milano, Apr. 1952, pp. 39–44; *Suppl. Ric. sci.* **22,** 5, 1952.

Author gives classification criteria of axial compressors of every type and states and analyzes efficiency factors; he also states that it is sometimes difficult to get high efficiencies when high prestage compression ratios are required. A technical solution requires that a proper compromise be reached between these two opposite requirements, both very important in aeronautical engineering.

From author's summary

258. **Eichenberger, H. P., Secondary flow within a bend,** *J. Math. Phys.* **32,** 1, 34–42, Apr. 1953.

The paper presents a theoretical solution and comparison with experiment for the secondary flow within a bend of a tube with rectangular cross section. The theory neglects viscosity and compressibility and utilizes linearized equations of motion for the secondary flow. The equations are solved for the initial conditions of constant stagnation pressure in the radial direction and linear decrease from the center to the upper and lower walls. The theoretical results agree well with experiments at the 30° station of an 8-in. × 8-in. square tube with a 90° bend of mean radius 28 in. The agreement is, however, only slightly better than it is for the simplified theory of Squire and Winter, which assumes two-dimensional flow and neglects changes in the direction of increasing bend angle. It is concluded that, for cases the same as or less severe than that investigated, the simplified theory is adequate for corrections to the flow in the blade passages of a compressor.

A. M. Kuethe, USA

259. **Patterson, A. M., Improvement of pressure recovery of a fixed diffuser by means of suction,** *J. Aero. Sci.* **20,** 6, 430–432, June 1953.

Note in Readers' Forum.

260. **Fraser, W. H., Hydraulic problems encountered in intake structures of vertical wet-pit pumps and methods leading to their solution,** *Trans. ASME* **75,** 4, 643–648, May 1953.

Valuable design information is presented concerning pump spacing, sump design, and deflector arrangements for vertical pumps in a single intake structure. Data are presented which indicate that higher intake-tunnel velocities are permissible with the suction scoop than with the suction bell.

M. R. Carstens, USA

261. **Iversen, H. W., Studies of submergence requirements of high-specific-speed pumps,** *Trans. ASME* **75,** 4, 635–638, May 1953.

Submergence requirements of high-specific-speed pumps that take suction from open sumps depend on a vortex formation in the sump and resulting air entrainment in the pumped liquid. Two interrelated requirements must be met in sump design. The sump must be of minimum size without adversely affecting pump performance with respect to head and efficiency. Laboratory studies have been made on the effect of side-wall and bottom clearances, relative to the suction bell, on pump efficiency, and also on the submergence requirements to avoid air entrainment. Results show that side-wall and end-wall clearances of one quarter to one half the suction bell diameter, and bottom clearances of one half the suction bell diameter, will not affect the normal pump performance adversely.

From author's summary by A. H. Church, USA

262. **Jones, D. H., Design and application of controlled-volume pumps for high pressure in the range of 10,000 to 30,000 psi,** *Trans. ASME* **75,** 3, 361–367, Apr. 1953.

The problems of reciprocating-plunger-type pumps for liquids at extremely high pressures are reviewed, and current practice in the design and use of such equipment is described.

J. V. Becker, USA

263. **Beighley, C. M., and Cheatham, T. E., Reduction of rocket motor performance data by means of IBM computing machines,** *J. Amer. Rocket Soc.* **23,** 3, 150–154, May-June 1953.

Experimental data of rocket motor performance and heat

transfer, obtained at the Rocket Laboratory of Purdue University, are evaluated on IBM punched-card machines. Force (thrust) and pressures are measured by reluctance transducer elements and recorded on automatic-balancing recording potentiometers. Calibration curves can be approximated by straight lines.

Measured values (normally at 5-sec intervals) and calibration points are punched on IBM cards (punching time for a 40-sec run about 70 min). IMB machines, including a 602 multiplying punch, are used for evaluating calibration curves (method of least squares) and desired quantities.

Method is considered faster, more accurate, cheaper, and more economical in the use of technical manpower than conventional method. S. Ekelöf, Sweden

264. Schroeder, J. H., Effect of vibrational excitation on the theoretical performance of the stoichiometric carbon-oxygen propellant system, *J. Amer. Rocket Soc.* **23,** 1, 25–27, Jan.-Feb. 1953.

The effect of the excitation of internal degrees of freedom (i.e., molecular relaxation) on the performance of the carbon-oxygen propellant system for nozzle flow is investigated. For this purpose, the performance is accurately evaluated for four cases: (a) During the flow both chemical and vibrational energy equilibrium are maintained; (b) vibrational energy is assumed in equilibrium, chemically the system is frozen (i.e., chemical composition remains unchanged); (c) chemically equilibrium, vibrationally frozen; (d) chemically and vibrationally frozen. The results show a 6% decrease between case (a) and (c), or, in other words, the performance of the system in chemical equilibrium decreases 6% as result of the vibrational lag. For the chemically frozen system [cases (b) and (d)] the vibrational lag produces 1% decrease in performance. H. L. Oestreicher, USA

265. Gas-turbine progress report—1952: Seippel, C., Gas turbines in our century; Sawyer, R. T., Introduction; Hafer, A. A., Materials, cooling, and fuels; Martinuzzi, P. F., Cycle components; Schwartz, F. L., Automotive; Browne, K. A., Yellott, J. I., and Broadley, P. R., Railroad; Dolan, W. A., Jr., and Hafer, A. A., Marine; Merchant vessels; Naval vessels; Schneitter, L., Stationary electric generation; Rowley, L. N., Jr., and Skrotzki, B. G. A., Industrial; Driggs, I. H., and Lancaster, O. E., Aviation, *Trans. ASME* **75,** 2, 121–234, Feb. 1953.

Report contains twelve articles which summarize the history and progress made, both abroad and in this country, in the various phases of gas-turbine engine and its various fields of application. Reviewer believes that these articles are useful to students, designers, and application engineers of gas turbines. He also feels that, in any future progress report, the fundamental knowledge gained by both theoretical and experimental investigations on the internal flow through compressor and turbine, as well as combustion phenomena, should be more adequately covered.

C. H. Wu, USA

Flow and Flight Test Techniques

(See also Revs. 10, 173, 208, 243, 286, 287, 323)

266. Pilny, M. J., A small Pirani gage for measurements of nonsteady low pressures, *NACA TN* 2946, 36 pp., June 1953.

A description is given of a small Pirani gage (0.005-cu-in. internal volume) made of surgical grain-of-wheat clamps, and the operating equipment for the recording of 12 channels of low pressures in the range 0.1 to 10 mm Hg abs. Techniques of calibration and use of this apparatus are described, and measurements are shown to contain errors not exceeding ±2% of reading, lags not exceeding 1 sec, and calibration shifts of 2% per year. These small Pirani gages appear to be well suited for static-pressure measurements in low-pressure supersonic tunnels and may be useful for other applications as well.

A theoretical analysis of a small Pirani gage is given and may be used as a guide in the design, application, and evaluation of such a gage. From author's summary by G. Rudinger, USA

267. Li, Y. T., Dynamic pressure measuring systems for jet propulsion research, *J. Amer. Rocket Soc.* **23,** 3, 124–127, 145, May-June 1953.

Pressure-measuring systems capable of accurate operation at temperatures and frequencies encountered in rocket research are discussed. It is concluded that a water-cooled strain-gage diaphragm indicator at present meets the requirements more closely than other types tested. One unit of this type performed satisfactorily at estimated temperatures up to 5000 F, but was destroyed after about one second of screaming operation during which the estimated temperature was about 6000 F.

W. E. Moeckel, USA

268. Chapman, D. R., Wimbrow, W. R., and Kester, R. H., Experimental investigation of base pressure on blunt-trailing-edge wings at supersonic velocities, *NACA Rep.* 1109, 19 pp., 1952.

Supersedes article reviewed in AMR **5,** Rev. 2117.

269. Goldberg, A., Design of a square-root-extracting, force-balance, pneumatic transmitter, including derivation of formulas, *Trans. ASME* **75,** 4, 501–506, May 1953.

This paper describes the design of a device which measures the differential pressure across an orifice and produces an air pressure proportional to its square root, i.e., proportional to the rate of flow. H. D. Huskey, USA

270. Willmarth, W. W., On the measurement of surface pressure with a static probe, *J. aero. Sci.* **20,** 6, 438–439, June 1953.

Note in Readers' Forum.

271. Bierlein, J. A., and Scheller, K., Methods of measuring thrust, *J. Amer. Rocket Soc.* **23,** 3, 128–132, May-June 1953.

Paper reviews design of rocket test beds and methods of thrust measurement. Various methods are described of mounting rocket motors for thrust measurement, and limitations of a variety of support systems are outlined. Authors review various instruments for directly measuring rocket thrust and indicate the ranges, accuracy, and limitations of commercially available instruments. They consider mechanical lever-type scales, hydraulic and pneumatic capsules, and resistance and inductance-type strain gages. Also included are descriptions of indirect methods of measuring thrust, including measurement of combustion-chamber pressure, integration of pressure over combustion chamber and nozzle, and optical methods of measuring exhaust velocity. Manufacturers of various thrust-measuring devices are listed and references are given for calculating jet thrust from indirect measurements. R. M. Crane, USA

272. Stehling, K. R., and Diamond, P. M., Flow controls, *J. Amer. Rocket Soc.* **23,** 3, 178–183, 185, May-June 1953.

A survey of the various types of valves available commercially or custom made. The role of the "accumulator" as a nonvalve type of control is outlined and its function as an energy-storing device and damper is emphasized. Cavitating Venturis, calming

chambers, flow-pulsing units, and an example of a rocket-firing stand are discussed. R. Betchov, USA

273. **Smith, A. G., Fletcher, G. L., Owen, T. B., and Wright, D. F., Towing tank tests on a large six-engine flying boat seaplane, to specification 10/46 Princess. I. General porpoising stability, trim and spray clearance,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2641, 29 pp., Jan. 1948, published 1953.

274. **Balint, E., Techniques of flow visualization,** *Aircr. Engng.* **25,** 292, 161–167, June 1953.

Paper surveys optical methods used in the study of incompressible flow, both of gases and liquids. The section on the principle of similarity includes a rather clear discussion of pertinent nondimensional parameters which govern the applicability of experimental results obtained with models, and of the approximations which are made in practice. The prospective researcher will find practical remarks on the use of oil drops, smoke, dyes, tufts, microphotogrammetry, shadow, schlieren, and streaming double-refraction, including theoretical elements of the last mentioned. Author feels that the optical methods will grow in importance with time and with improvements in technique, particularly at moderately high Reynolds numbers. This is perhaps so, although the development may be somewhat limited by the fact that the principal quantitative optical procedures are integrative in nature and cannot, in general, be applied to three-dimensional flow phenomena. D. Bershader, USA

275. **Werlé, H., Visualization in hydrodynamic tunnel** (in French), *Rech. aéro.* no. 33, 3–7, 1953.

Author describes very briefly four methods for visualization of stream direction in a water tunnel, which, in two cases, even allow one to get an impression of velocity of stream. Methods are illustrated by twelve photographs. S. F. Erdmann, Sweden

276. **Vogel, W., Performance analysis of exhaust gas turbines** (in German), *Motortech. Z.* **14,** 5, 149–155, May 1953.

Author calculates performance characteristics of single-stage and two-stage gas turbines at design and off-design point. The results are given graphically. Assumptions on speed coefficient, loss coefficients, etc., are rather arbitrary. There is a distinct lack of clear definitions of symbols used. Sometimes a quantity is multiplied or divided by enthalpy without a statement of the energy constant adopted. L. S. Dzung, Switzerland

277. **Hurden, D., Rocket motor testing,** *J. Brit. interplanetary Soc.* **12,** 3, 101–113, May 1953.

Paper describes in broad outline the tests applied to such rocket motor components as valves, pumps, and turbines and treats rather more fully the problems of testing combustion chambers and complete motors. Finally, the flight testing of rockets is touched upon and the requirements of production testing are briefly discussed. From author's summary

278. **Warnick, C. C., Experiments with windshields for precipitation gages,** *Trans. Amer. geophys. Un.* **34,** 3, 379–388, June 1953.

Amount of precipitation caught by rain or snow gage is seriously affected by wind speed; ratio of actual catch to theoretical catch decreases with increasing wind. Paper describes experiments conducted in wind tunnel with various types of windscreens intended to alter flow regime near gage mouth so as to eliminate updraft at mouth occurring with unshielded gage. Fine sawdust was used to simulate snow. Flash photos of sawdust and smoke were used to study flow regime; in addition, the weight of sawdust caught was recorded and compared with theoretical amount. The latter was calculated from actual density and velocity of sawdust particles obtained by sequential flash photos against a ruled grid background. Most effective shield increased catch from 27% (with unshielded gage) to 60% with wind equivalent to 23 mph. Most effective shield is modification of Alter shield to allow freer swinging of baffles and to prevent bunching of baffles. Field tests on mountains in snow tend to corroborate tunnel test results. Reviewer regards this work as a very valuable study, since previous tests have been largely qualitative in character. E. W. Barrett, USA

279. **Irving, F. G., A note on the theory of the constant-area mixing of compressible flows as applied to high-speed wind tunnel design,** *Aero. Quart.* **4,** part II, 164–178, Feb. 1953.

A one-dimensional analysis is made of the mixing of two parallel gas streams similar to that of Bernstein in *NACA TN* 2918. The answers do not agree, Irving's Eqs. 5, 8, and 14 being in error. (L_3/N_3) in these equations should be written (N_3/L_3). The analysis is then applied to a supersonic induction wind tunnel by calling one of the parallel streams the main induced supersonic flow and the other the injected stream. A comparison of the required amount of injected air for a sonic injection velocity and for injection velocity equal to that of the supersonic main flow indicates that less air is required if it is injected at supersonic speed. These computations appear to be correct. As the author points out, however, the method does not account for the actual mechanism of mixing. L. H. Schindel, USA

280. **Goodman, T. R., The upwash correction for an oscillating wing in a wind tunnel,** *J. aero. Sci.* **20,** 6, 383–386, 406, June 1953.

See AMR **5,** Rev. 1856.

281. **Favre, A., Gaviglio, J., and Dumas, R., Some correlation for time and for space measurements in wind tunnels** (in French), *Rech. aéro.* no. 32, 21–28, 1953.

Hot-wire anemometer measurements in a wind tunnel and their corresponding results are reported. First, authors determined autocorrelation, i.e., correlation for a single point located downstream from a lattice screen at 40 M (M was the mesh length of lattice) and for several Reynolds numbers. Corresponding spectra of turbulence are compared with the ones obtained by Dryden, and Stewart and Townsend. Next, authors studied correlation for two distinct points located in the direction of the main stream. They were able to verify Taylor's hypothesis that longitudinal correlation curves are similar to temporal ones, provided there is slight turbulence, the main flow is straight and uniform, and the time for autocorrelation is that needed to travel the distance between the two points at the main flow velocity. Later, authors studied temporal-longitudinal correlation. When measurements at the second point were made at the time needed for the main flow to travel from the first, there were observed great values of correlation in spite of the fact that distances were enough to give nul values for simultaneous determinations. Temporal-traversal correlations with and without delay were also studied.

Finally, authors studied the spectra of turbulence in the boundary layer of a plate. A. Balloffet, Argentina

282. **Thom, A., Tunnel wall effect from mass flow consideration,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2442, 10 pp., Nov. 1947, published 1952.

Corrections to experiments in closed two-dimensional wind tun-

nels at high subsonic Mach numbers are investigated. Correction obtained is for solid blockage of airfoil-type models at zero lift and is given in the usual form of a blockage factor $\Delta u/u$ to be applied to tunnel speed. Present report attempts to obtain analytically the results already obtained arithmatically in *Rep. Mem.* 2385, 1946.

Method used equates mass flow upstream to that past the maximum thickness point of the model. Velocity profile at latter station is assumed equal to that for the same model in free air at corrected tunnel speed. This profile is obtained by Prandtl-Glauert correction to incompressible solution. Integration at model station is carried out analytically, using series approximations, giving relation between tunnel air speed and equivalent free air speed.

For speeds somewhat below choking, a simple two-term expression is obtained for the blockage factor. The first term is identical with that obtained by images and small perturbation theory, proportional to $1/(1 - M^2)^{3/2}$. The second term is proportional to $1/(1 - M^2)^{5/2}$. Good agreement is indicated by author with numerical methods of solution. Reviewer finds good correlation with velocity ratio method for model with 3% blockage up to uncorrected $M \approx 0.82$. J. A. F. Hill, USA

283. Zingg, A. W., Wind-tunnel studies of the movement of sedimentary material, Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 111–135, 1953.

In a first group of experiments, author laid surfaces of stabilized sand in the wind tunnel. He obtained distribution $u(y)$ in the air current, direct measure of τ_0 (average shear on sand surface), and total pressure P_1 in the transition section between fan and duct. For the first group, he finds that K, the universal constant for turbulent flow, equals 0.40, and that height at which the velocity curve intersects the y axis is a logarithmic function of grain diameter.

In a second group of experiments, surfaces of drifting sand were laid in tunnel. In addition to $u(y)$, τ_0, and P_1, sand rates were measured at varying y by means of samples collected during the entire period of two minutes which corresponded to one test. For the second group, K is found ~ 0.375. Author's subsequent deductions on the particles movement are strictly dependent on the experimental procedure. M. Viparelli, Italy

284. van Heel, A. C. S., Precision refractometer with simple measuring prism, *Appl. sci. Res.* (*B*) **3,** 2, 119–128, 1953.

Thermodynamics

(See also Revs. 181, 264, 317, 364, 369)

285. Mooney, D. A., Mechanical engineering thermodynamics, New York, Prentice-Hall, Inc., 1953, xi + 540 pp. $7.

The book is intended for the general undergraduate course in thermodynamics required of mechanical-engineering students. Twenty-five chapters having the following titles make up the text: Introduction, Work, Temperature and heat, Properties of systems, The first law of thermodynamics, Flow processes—First law analysis, The second law of thermodynamics, Basic applications of the second law, Properties of pure substances, Tabulated properties—steam tables, Properties of gases, Properties of gaseous mixtures, Process calculations for stationary systems, Vapor cycles—The rankine cycle, Vapor cycles—More efficient cycles, Gas cycles, Fluid-flow nozzles and orifices, Turbines, Reciprocating expanders and compressors, The steam engine, Gas compression, Combustion processes—First law analysis, Internal combustion power plants, Refrigeration, Air-water vapor mixtures. In addition, extensive thermodynamic data and Mollier-type charts are included.

The balance between material explained and that mathematically derived is good. The approach is mature. A liberal number of simple but excellent figures facilitates understanding the material. One unique characteristic of the text is that the author categorically states facts which in many books can be obtained by inference only. He is thus helping students who generally have not had the maturity to read between the lines. Another novelty is the inclusion of combustion charts. The Mollier chart for steam is found in the back-cover pocket of the book, but it is difficult to understand why E. F. Leib's chart was reproduced while the steam-table data are abridged from Keenan and Keyes' well-known work. This seems inconsistent. The style, too, is inconsistent, being poor in spots. In fact, the book is difficult to read. There are many statements which are incomplete or, at best, trivial. A typically disturbing statement may be found on page 227 which reads: "The actual engine or turbine is certainly not reversible . . . ." Thermodynamically speaking, it is a process which may or may not be reversible, not a device.

A. B. Cambel, USA

286. Fiock, E. F., and Dahl, A. I., The measurement of gas temperature by immersion-type instruments, *J. Amer. Rocket Soc.* **23,** 3, 155–164, May-June 1953.

Available methods and instruments are reviewed and intercompared, particularly with regard to applications in turbines and jet engines. Means for reducing and evaluating effects of radiation and gas impact upon performance of instruments are shown to be of considerable importance in such applications. The rate of response to sudden changes in temperature together with ranges of applicability, and methods of construction and insulation required to withstand engine-operating conditions, are discussed for bare, sheathed, shielded, and aspirated thermocouples, for resistance-type elements, and for several pneumatic or thermodynamic systems. From authors' summary by G. Rudinger, USA

287. Dyne, P. J., and Penner, S. S., Optical methods for the determination of combustion temperatures, *J. Amer. Rocket Soc.* **23,** 3, 165–169, May-June 1953.

Principles, experimental procedure, and general remarks are given briefly for seven methods of measuring temperature of isothermal emitters and two for nonisothermal emitters. An extensive list of references is included. J. C. Wisdom, Australia

288. Corruccini, R. J., and Shenker, H., Modified 1913 reference tables for iron-constantan thermocouples, *J. Res. nat. Bur. Stands.* **50,** 5, 229–248, May 1953.

Investigation was made of characteristics of typical commercial IC thermocouples to reproduce standard temperature-emf relationship established in 1913. Using calibration of thermocouple that most nearly matched 1913 reference table from 32 to 1400 F, a slightly different temperature-emf relationship was derived which is more nearly realizable by commercially available materials. From authors' summary by W. J. Anderson, USA

289. Rosen, P., On variational principles for irreversible processes, *J. chem. Phys.* **21,** 7, 1220–1221, July 1953.

Modified variational principles for diffusion problems and incompressible viscous flow are derived by applying Green's theorem to the original variational principle and noting that the surface integral does not contribute to the Euler-Lagrange equation. W. Squire, USA

290. **Zwanzig, R. W., Kirkwood, J. G., Stripp, K. F., and Oppenheim, I., Radial distribution functions and the equation of state of monatomic fluids,** *J. chem. Phys.* **21,** 7, 1268–1271, July 1953.

An approximation is obtained for the radial distribution function in a fluid whose molecules interact with the Lennard-Jones potential. Calculations of the equation of state, the internal energy, and the compressibility are presented and compared with experiment. At temperatures and volumes higher than the critical, agreement with experiment is satisfactory. A systematic method is developed of modifying the theoretical radial distribution function so that calculated thermodynamic quantities agree with their experimental values. In the liquid phase, slight modifications are needed to obtain agreement with experiment.

From authors' summary by R. A. Gross, USA

291. **Charnley, A., Isles, G. L., and Townley, J. R., The direct measurement of the isothermal Joule-Thomson coefficient for gases,** *Proc. roy. Soc. Lond.* (*A*) **218,** 1132, 133–143, June 1953.

A new apparatus is described for measuring the isothermal Joule-Thomson coefficient. The results obtained agree well with other direct measurements and also with adiabatic Joule-Thomson and compressibility data. The gases which have been investigated are nitrogen, ethylene, carbon dioxide, and nitrous oxide, in the range 0 to 45 C and 0 to 45 atm.

From authors' summary

292. **Woolley, H. W., The representation of gas properties in terms of molecular clusters,** *J. chem. Phys.* **21,** 2, 236–241, Feb. 1953.

The equation of state of a gas in virial form is derived from the equilibrium constants for the formation of molecular clusters. It is indicated that, by choosing effective Lennard-Jones parameters independently for clusters of various numbers of molecules, the actual virial coefficients may be represented more satisfactorily. Results for the third virial coefficient are shown for A, N_2, CO, CO_2, CH_4, C_2H_4, CF_4, and Xe.

From author's summary

293. **Tsien, H. S., The properties of pure liquids,** *J. Amer. Rocket Soc.* **23,** 1, 17–24, Jan.-Feb. 1953.

Author shows, by postulating appropriate molecular model, with specified bimolecular interactive potential, that for liquids $C_v^l = C_p^g + 0.5R - 0.4RT/T_b$ (T_b is normal boiling temperature), analysis does not predict coefficient of expansion α or compressibility β accurately, but reveals that dimensionless groups αT_b and $\beta RT_b/V_l$ (V_l is vol of liquid) should depend only on (T/T_b). Comparison to available data suggests empirical relation good to $\pm 10\%$ for most liquids. Using well-known thermodynamic relations and generalized curves of (αT_b) and $(\beta RT_b/V_l)$ vs. (T/T_b), author shows further that, except near boiling point, $C_p^l - C_p^g \sim 10$ cal/°C mole, except for cases where liquid appears to represent different molecular weight than gas. After discussion of velocity of sound in liquids, author shows that thermal conductivity for many liquids can be predicted ($\pm 20\%$) from density, molecular weight, and normal boiling point by $\lambda = (\beta\rho)^{-1/2}(M/N\rho)^{1/3}(3R\rho/M)$ where M is mol wt, ρ density, N Avogadro number.

M. Tribus, USA

294. **Heath, H. R., The viscosity of gas mixtures,** *Proc. phys. Soc. Lond.* (*B*) **66,** part 5. 401B, 362–367, May 1953.

Measurements of the viscosity of gas mixtures are reported for (a) a monatomic gas mixed with a monatomic, a diatomic, and a polyatomic gas, and (b) a diatomic gas mixed with a monatomic, a diatomic, and a polyatomic gas. The gases used were He, A, N_2, H_2, and CO_2. A Rankine-type viscometer was used to obtain the experimental data for a complete range of concentrations, and all measurements were made at 18 C and 700-mm Hg pressure. The results are compared with the first approximation to viscosity for mixtures from Chapman's theory. Good agreement between theory and experiment is shown; the interesting property of initially increasing the viscosity by adding a less viscous gas to a denser more viscous gas is verified as well as a comparable effect of initially increasing viscosity by adding a denser less viscous gas to a monatomic gas.

F. K. Hill, USA

295. **Srivastava, B. N., and Madan, M. P., Thermal diffusion of gas mixtures and forces between unlike molecules,** *Proc. phys. Soc. Lond.* (*A*) **66,** 399A, part 3, 278–287, Mar. 1953.

The coefficient of thermal diffusion is very sensitive to the intermolecular forces. Applying the Chapman-Enskog theory of thermal diffusion, the authors calculate the two constants in the Lennard-Jones intermolecular potential from thermal diffusion measurements.

H. C. Brinkman, Indonesia

296. **Best, A. C., The relative humidity in radiation fog,** *Tellus* **5,** 1, 32–35, Feb. 1953.

Relative humidity in radiation fog is governed by the rate at which water condenses onto hygroscopic nuclei and by rate of fall of temperature. An equation describing this is developed and it is deduced that, with the usual rates of fall of temperature and salt content of the air, the relative humidity is unlikely to exceed $100.1^{\circ}_{\circ}$.

From author's summary by D. A. de Vries, Holland

297. **Leiker, M., Ignition processes and combustion characteristics of Diesel motors and gasoline motors** (in German), *Motortech. Z.* **14,** 6, 161–174, June 1953.

Author considers the influence of type and concentration of the fuel upon ignition retard and ignition limits, detonation stability, and combustion velocity for the Diesel, Otto, and compound process. Formulas for air ratio depending on composition and quantity of the waste gas remaining in the cylinder are given. By means of experiments with the Diesel engine, the influence of waste gas and fuel type upon the combustion process is examined; indicator diagrams are given. In Otto engines the influence of waste gas upon ignition, combustion process, and heat transformation in the case of high ratio of compression is investigated. In the compound process the compressed air-gas mixture is ignited by an oil spray. It is distinguished by small consumptions at full load and can work with poor mixtures. The possibility of speed regulation by dosing the ignition oil is examined for combinations of generator gas and gas oil, lighting gas and gas oil, propane and gas oil, methane and gas oil, the latter one being the most suitable for this process.

H. Krüger, Germany

298. **Sänger, E., Theoretical foundations of jet propulsion** (in German), *VDI-Forschungsheft* **437,** 5–25, 1953.

The report is essentially a summary of previous papers by the author, partly in collaboration with I. Bredt (35 out of 47 references are by the author), on possibilities for jet propulsion offered by present-day knowledge of physical laws. Already realized propulsion systems like piston-engine-propeller, turbojets, ramjets, solid and liquid-fuel rockets are discussed in their ranges and limitations, as well as contemplated rockets which use atomic energy to accelerate light-weight gases and the hypothetical propulsion systems like atomic rockets without mass addition, photon rockets, as well as use of radiation pressure of sun radiation. General basic equation for a jet-propulsion unit is developed on

basis of relativistic mechanics. (To reviewer, the exact meaning of the acceleration as felt physiologically by the crew of a space ship is not clear and therefore some parts in the derivation could not be followed.) E. R. G. Eckert, USA

299. Sänger-Bredt, Irene, General analysis of optimum conditions for multistage rockets ascending vertically against gravity (in German), *VDI-Forschungsheft* **437,** 26–39, 1953.

Optimum values of performance parameters such as ratio of propellant weight to thrust are calculated under various conditions. The optimizations are made with respect to each of the quantities, burnout-velocity, burnout-altitude, and maximum altitude, and are calculated for vertical, drag-free trajectories with both thrust and gravity held constant, or constant during each stage.

In the analysis, the reference parameters are the dimensionless ratios: motor-weight/thrust, fuselage-weight/gross-weight, tank-weight/propellant-weight, payload/empty-weight, payload/gross-weight. This choice of parameters suggests, for example, that optimum thrust is calculated under the assumption that motor-weight is proportional to thrust. For another analysis of multistage rockets, cf. AMR **1,** Rev. 1953. J. Lorell, USA

300. Sivori, V., Typical problems connected with missiles using liquid fuels (in Italian), *Aerotecnica* **33,** 1, 118–122, Feb. 1953.

301. Kölle, H. H., On the determination of the optimal pressure in combustion chambers of rocket motors (in German), *Weltraumfahrt* no. 1, 9–15, Jan. 1953.

An approximate method is developed for the determination of the effects of combustion-chamber pressure on the starting and net weights of rocket motors. An optimal pressure may be chosen so that the total cost of the rocket is a minimum. The results of a typical example using N_2H_4 and O_2 are presented in graphical form. Author believes that the method is applicable for a single-stage rocket or for the first stage of a multistage rocket. T Y. Toong, USA

302. Smalley, H. F., and Sosman, R. B., A comparison of gas-fired pyrometric cone equivalent furnaces, *Bull. Amer. ceram. Soc.* **32,** 1, 5–11, Jan. 1953.

303. Crocchi, P., Present state of small power turbojets (in Italian), Conv. Stud. Propul. Reaz., Milano, 59–65, Apr. 1952; *Suppl. Ric. sci.* **22,** 5, 1952.

The present state of small power turbojet techniques is examined, together with the practical prospect of their use on aircraft and the progress that may be foreseen in this field, particularly as to the fuel consumption.

From author's summary

Heat and Mass Transfer

(See also Revs. 156, 157, 160, 181, 182, 183, 216, 235, 285, 294, 295, 346)

304. Rouse, H., Baines, W. D., and Humphreys, H. W., Free convection over parallel sources of heat, *Proc. phys. Soc. Lond.* (*B*) **66,** part 5, 401B, 393–399, May 1953.

An experimental investigation was carried out of the velocity and temperature distributions in otherwise still air over parallel linear heat sources (as used during the war for fog dissipation over airports). The results are presented dimensionlessly as ratios, including temperature or velocity plotted against the lateral and vertical position relative to the source spacing. Velocity and temperature results correlate reasonably well separately and agree moderately well among each other by a momentum balance. A surprising conclusion is that the highest temperatures and velocities are between the sources, rather than over them. This is a first approximation solution to a very complex problem, but should help in estimating heat requirements for fog dissipation.

C. F. Bonilla, USA

305. Rich, B. R., An investigation of heat transfer from an inclined flat plate in free convection, *Trans. ASME* **75,** 4, 489–499, May 1953.

The differential equation for heat transfer from inclined plates in free convection was derived in dimensionless form. The flow must be laminar and two-dimensional. Heat transfer from a flat plate in free convection was studied for angles of inclination from 0 to 40 degrees measured from the vertical for Grashof numbers from 10^8 to 10^9, and temperature differences from 200 to 260 F. The investigation shows that the equation for vertical flat plates will give the unit thermal conductance for an inclined plate within 10% when the Grashof number is modified by the cosine of the angle of inclination. The discussers raise some question about the validity of some of the assumptions and recommend additional investigations. R. M. Wingren, USA

306. Ostrach, S., An analysis of laminar free-convection flow and heat transfer about a flat plate parallel to the direction of the generating body force, *NACA Rep.* 1111, 17 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 3233.

307. Cary, J. R., The determination of local forced-convection coefficients for spheres, *Trans. ASME* **75,** 4, 483–487, May 1953.

Local heat-transfer coefficients were determined for a 5-in. diam sphere located in a 15-in. diam air duct for Reynolds number varying from 44,000 to 151,000. Ambient air was used as the fluid. The heat-transfer coefficient reached a minimum value at 105° from the stagnation point and a maximum value at 180° from the stagnation point. Values for the average coefficient were 50% lower than those obtained from McAdams' textbook. More experimental results are needed from other investigators before anything definite can be concluded as to the value of the data. However, the author appears to have done a fine piece of work.

R. J. Mindak, USA

308. Parker, E. N., The effect of turbulence on heat transfer in a pile with a liquid reactant, *J. appl. Phys.* **24,** 4, 451–452, Apr. 1953.

Fully developed turbulent flow in a channel is considered theoretically from the standpoint of the effect of channel width on the heat transfer to the walls. For a given temperature difference between the walls and the fluid, the total heat transfer decreases with increasing channel width if the mean velocity remains the same, assuming that the heat-transfer coefficient is independent of the spacing. A. M. Kuethe, USA

309. Tifford, A. N., An exact thermal solution in laminar viscous flow, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 783–788, 1952.

Author obtains a series solution of the complete energy equation for two-dimensional flow of a viscous, incompressible fluid in the neighborhood of a forward stagnation region. The velocity field is assumed to be given by the Blasius-Hiemenz exact solution of the Navier-Stokes equations. Author retains in the energy equation the terms representing heat conduction in the direc-

tions parallel to the boundary. The usual solutions of the approximate heat equation in which these conduction terms are neglected are based on the assumption that the second partial derivatives of the wall temperature are sufficiently small. Author shows that even if this condition is satisfied the approximate solution will be erroneous near the stagnation point if the fourth or higher even derivatives of the wall temperature are large.

G. W. Morgan, USA

310. **Furukawa, G. T., and McCoskey, R. E., The condensation line of air and the heats of vaporization of oxygen and nitrogen,** *NACA TN* 2969, 30 pp., June 1953.

The condensation pressure of air was determined over the range of temperature from 60 to 85 K. The experimental results were slightly higher than the calculated values based on the ideal solution law.

Heat of vaporization of oxygen was determined at four temperatures ranging from about 68 to 91 K and similarly of nitrogen at four temperatures ranging from 62 to 78 K.

From authors' summary

311. **Brooks, R. D., and Rosenblatt, A. L., Nuclear power plants. Design and performance of liquid-metal heat exchangers and steam generators,** *Mech. Engng., N. Y.* **75,** 5, 363–368, May 1953.

The paper describes the performance of liquid-metal heat exchangers and steam generators which were in operation at Knolls atomic power laboratory. A number of design and construction details are also briefly discussed. The main streams of the heat exchangers are of sodium and NaK, while steam and NaK form the cold and hot streams of the steam generator. In both cases, the main streams are separated by a third buffer fluid which reacts with neither of them and serves as a leak detector.

Two types of heat exchangers were tested—the flat-tube exchanger and shell-and-tube exchanger. Experimental results are presented in the form of graphs by plotting the over-all heat-transfer coefficient against NaK Reynolds number.

The steam generators tested were of the forced-circulation and natural-circulation types. They both consist of steam drums, evaporators, and a superheater section. In the superheater, the steam film is the controlling resistance. Results are given as a function of the steam Reynolds number. In the evaporator, the principal thermal resistance is in the tube wall. The over-all heat-transfer coefficient is plotted against NaK Reynolds number.

The over-all heat-transfer coefficients U reported in the paper were obtained in the usual way, i.e., from the expression $U = Q/Ax(LMTD)$. The shell-side heat-exchanger coefficients were obtained by evaluating the individual coefficients. Authors claim that, for both the shell-and-tube heat exchanger and forced- and natural-circulation evaporator, they could be obtained from the equation: $Nu = 61.2\ [Re \cdot Pr(A_E/A_H)^2]^{0.6}$, with a mean deviation of ±15%.

B. T. Chao, USA

312. **Poppendiek, H. F., Liquid-metal heat transfer,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 77–100, 1953. $5.

Paper presents a review of experimental and theoretical liquid-metal heat-transfer information and also detailed analysis of forced convection heat transfer in a thermal entrance system. The analysis is restricted to systems characterized by low Prandtl moduli and low and intermediate Reynolds moduli. Forty-one references are listed on liquid-metal heat transfer.

Reviewer feels the paper to be a useful brief summary of the situation in this field.

W. A. Wolfe, Canada

313. **Rainville, E. D., A heat conduction problem and the product of two error functions,** *J. Math. Phys.* **32,** 1, 43–53, Apr. 1953.

Author gives dual solutions in rectangular and polar coordinates for an elementary transient heat-conduction problem in which the rectangular solution $u(x,y,t)$ appears as the product of two error functions $erf(x,t)erf(y,t)$ and the polar solution appears as a confluent hypergeometric function ${}_1F_1(r,\theta,t)$. An interesting series expansion for the product of two error functions is then obtained by equating the two solutions of the same problem.

P. J. Schneider, USA

314. **Churchill, R. V., Comparison of temperatures in solid bodies and their scaled models,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 283–286, 1953. $5.

By dimensional analysis, the relation is found between the steady-state temperature of two geometrically similar solid bodies made up of the same homogeneous and isotropic material and with heat transferred by conduction to their interiors.

S. I. Pai, USA

315. **Korst, H. H., Mean temperature difference in multipass cross-flow heat exchangers,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 949–955, 1952.

An analytical method is presented for determining in dimensionless form the mean temperature difference in multipass cross-flow heat exchangers for which solutions have not been given previously. The mathematics is in the form of a characteristic initial value problem of a partial-differential equation of second order, hyperbolic type. Solution is accomplished numerically with finite difference equations. The process is illustrated by solving the case of two-pass cross-flow heat exchanger with both fluids unmixed.

W. M. Rohsenow, USA

316. **Coulbert, C. D., Mach-Zehnder interferometer applications as used in the study of convection and conduction heat-transfer systems,** ASME Ann. Meeting, New York, Dec. 1952. Paper no. 52—A-9, 3 pp., 13 figs.

Author discusses in general terms the possible applications of the Mach-Zehnder interferometer in heat-transfer studies and suggests its broader potential used as a versatile tool in convection and conduction heat-transfer experiments. He presents briefly the advantages and disadvantages of the interferometer over the more conventional use of thermocouples to make temperature measurements in systems undergoing rapid transient phenomena. Several examples are presented together with results where applications in convective and conductive systems are covered.

Y. S. Touloukian, USA

317. **Mattarolo, L., Heat-transfer characteristics of some refrigerants** (in Italian), *Ricerche* no. 1, 27–50; *Suppl. Termotecnica* **7,** no. 5, 1953.

A treatise on the experimental determination of heat-convection film coefficients of most commonly used refrigerants: NH_3, SO_2, CH_3Cl, CO_2, F-11(CCl_3F), F-12(CCl_2F_2), F-21($CHCl_2F$), F-22($CHClF_2$), F-113($C_2Cl_3F_3$), F-114($C_2Cl_2F_4$). First section of the work contains a valuable presentation of the heat-transfer properties of the liquid and vapor of the refrigerants listed above, for a temperature range of −40 C to 80 C. The heat-transfer analysis contains (a) the heat convection by the liquid refrigerants flowing through a tube, through an annular section, parallel flow along the outer walls of a tube, perpendicular flow aross the outer walls of a tube; (b) heat convected by the refrigerant in vapor state; (c) heat convection with condensing vapors; (d) heat convection with boiling.

Author in his analysis makes use of the generally used heat-convection expression, $Nu = aRe^bPr^c$, where the coefficients and exponents a, b, c are determined by experimental investigation. Last section of article contains condensed charts of heat-transfer coefficients for the benefit of the designer using the refrigerants listed previously. S. Eskinazi, USA

Acoustics

(See also Rev. 114)

318. Parthasarathy, S., and Bakhshi, N. N., Relation between velocity of sound and viscosity in liquids, *Proc. phys. Soc. Lond.* (*B*) **66,** part 5, 401B, 368–370, May 1953.

A relationship between the velocity of sound v and the viscosity η of the liquid medium has been established from experimental data. The formula $v^{1/3}\rho^{-1} = A + B\eta^{-1/3}$, where ρ is the density of the liquid, is shown to hold for the homologous series of liquids tested. It is observed that A is a constant for all samples investigated, whereas B is a function of the type of liquid. The authors cannot explain the significance of the constant A. M. S. Macovsky, USA

319. Shaw, E. A. G., The attenuation of the higher modes of acoustic waves in a rectangular tube, *Acustica* **3,** 2, 87–95, 1953.

Author has studied the attenuation of (1,0) waves in a rectangular tube in the 2.4 . . . 3.0 kc/s region using a probe microphone technique. His results lend support to Kirchhoff's classical treatment, which allows for the finite viscosity and thermal conductivities of the gaseous medium in a plane wave propagation in a cylindrical tube. Agreement is good within 2%. The ratio of viscous to thermal conduction losses for higher-order mode is found to be dependent upon the frequency and geometrical configuration of the waves, contrary to the plane wave case. His suggestion that this may provide a method of determining both the shear viscosity and thermal conductivity of gases is worth trying. G. S. Verma, India

320. Lippert, W. K. R., The practical representation of standing waves in an acoustic impedance tube, *Acustica* **3,** 3, 153–160, 1953.

Diagrams taken from the envelope curves of the periodic wave pattern in an acoustic tube with attenuation are given, which are of special usefulness in impedance measurements. Probe tubes with different orifices are used and the resultant shift of the pressure minima is discussed. Special test measurements with a rigid terminal are suggested for specifying the tube performance. F. E. Borgnis, USA

321. Schoch, A., Remarks on the concept of acoustic energy, *Acustica* **3,** 3, 181–184, 1953.

Trying to derive the conventional expressions for acoustic energy and energy flux from the exact hydrodynamical expressions, one is left with some extra terms which have given rise to some discussion. It is shown here that the exact expressions can be split up in such a way that (a) the troublesome terms are contained in the first terms only, (b) the second terms reduce to the usual formulas in the acoustic approximation, and (c) the conservation equation is exactly satisfied by the second terms separately. L. J. F. Broer, Holland

322. Exner, Marie-Luise, and Böhme, W., Measurement of sound insulation for flexural waves (in German), *Akust. Beihefte* no. 1, 105–110, 1953.

One cause of poor sound insulation is the spreading of a disturbance from one room to another by means of flexural waves in walls. Authors report on an experimental investigation of transmission of flexural waves between two beams connected by a layer of insulating material. For thin layers, transmission loss is zero at a frequency which varies inversely with the ratio of Young's modulus to shear modulus and directly with stiffness of the layer; hence, a cork layer has a lower perfect transmission frequency than a rubber layer of the same stiffness. [Theoretical analysis by Cremer, "The propagation of structure-borne sound," Dept. Sci. and Ind. Res. Sponsored Research (Germany), Rept. no. I (Ser. B).]

For thick layers, resonance phenomena give rise to transmission maxima at certain frequencies. Corresponding transmission losses vary inversely with the solid damping of the insulating material. M. C. Junger, USA

323. Parbrook, H. D., An acoustic interferometer for high fluid pressure, *Acustica* **3,** 2, 49–54, 1953.

An acoustic interferometer for high fluid pressure is described. Some of the problems of insuring a plane uniform field are discussed. A method is given for indicating the efficiency of crystal holders, and comment is made on some frequently recommended holders. From author's summary by H. L. Bloom, USA

324. Hubbard, H. H., Propeller-noise charts for transport airplanes, *NACA TN* 2968, 47 pp., June 1953.

Calculations of rotational-noise and vortex-noise levels at a distance of 300 ft for engine ratings of 1000 to 10,000 hp have been made for a large number of propellers in static operation. Propellers with three, four, six, and eight blades and diameters of 8, 12, 16, and 20 ft are considered. The results are presented in chart and table form for rapid estimation of the noise levels and spectrums in the range of tip Mach numbers from 0.40 to 1.00. Applications of the data to tandem and dual-rotating configurations are given and the supersonic-type propeller is also briefly considered.

It is emphasized that, if noise reductions are to be obtained or if present noise levels are to be maintained for higher power ratings, future propeller designs should operate at lower tip Mach numbers than are currently being used. Single- rather than dual-rotating propellers were found to generate the lowest over-all noise levels for a given number of blades. From author's summary

325. Veneklasen, P. S., Noise control for ground operation of the F-89 airplane, *J. acoust. Soc. Amer.* **25,** 3, 417–422, May 1953.

Design, construction, and testing of noise muffler for ground testing of F-89 airplane (two turbojet engines) are described. The comparatively cheap construction was effective, judged in terms of neighborhood relief and protection of operating personnel. Reviewer believes this is a good example of possibilities of present-day "engineering" acoustics, using only simple (octave-band analysis) measurements. P. H. Parkin, England

326. Hubbard, H. H., and Lassiter, L. W., Experimental studies of jet noise, *J. acoust. Soc. Amer.* **25,** 3, 381–384, May 1953.

Model studies on subsonic air jets from 3/4 to 12 in. in diam. emerging into still air, show results in general agreement with those from turbojet engines. The predominant source of the sonic radiation at high jet velocities is axial turbulence in the mix-

ing region. The direction of maximum radiation is at an off-axis angle which increases with sound speed. Over-all sound pressure at 90° off axis increases with a power of jet velocity lying between 2.1 to 3.7; Lighthill's theory [*Proc. roy. Soc. Lond.* (*A*) **211**, 564–587, 1952] predicts 4.0. The spectra of noise and turbulence are similar and show the same frequency of maximum. This frequency increases directly as jet velocity, inversely as nozzle diameter, and decreases with increasing distance from the jet. Peak sound pressures from a 1-in. jet reached practically one atmosphere close to the jet. These facts help explain some of the structural failures observed when resonance conditions are fortuitously attained. V. Salmon, USA

327. **Hardy, H. C., Noise control measures for jet engine test installations,** *J. acoust. Soc. Amer.* **25,** 3, 423–428, May 1953.

Paper is a survey of the acoustical engineering methods used to control aircraft noise for jet-engine test installations. The attenuation necessary, air capacity, and required cross-sectional area are discussed. Author gives nonmathematical descriptions of three types of quieting devices, viz., steel mufflers, duct baffles and splitters, and acoustically lined plenums. The importance of scale models is emphasized. Attention is called to radiation from the walls and the numerous other factors which must be considered. Reviewer feels article is an excellent survey for workers in allied fields. E. Ackerman, USA

328. **Powell, A., On the noise emanating from a two-dimensional jet above the critical pressure,** *Aero. Quart.* **4,** part II, 103–122, Feb. 1953.

Schlieren pictures of flow from a small-scale converging two-dimensional air jet above the critical pressure are examined. Existence of an instability displaying an antisymmetric pattern is established. Elementary theory connecting stream disturbances with radiated sound is suggested. H. R. Ivey, USA

329. **Ingard, Uno, A review of the influence of meteorological conditions on sound propagation,** *J. acoust. Soc. Amer.* **25,** 3, 405–411, May 1953.

Paper surveys sound-propagation studies in the atmosphere, at frequencies below 5 kc. The attenuating and refractive effects of the composition of the medium, temperature, wind conditions, and turbulence are discussed individually. Emphasis is placed on the possible application of these studies to the problem of aircraft noise. A sizable bibliography is included to which the reviewer would add the text by Blokhintzev, "Acoustics of an inhomogeneous, moving medium" [Moscow, 1946], translated by Beyer and Mintzer [Research Analysis Group, Brown University, 1952]. R. T. Beyer, USA

330. **Eckart, C., The scattering of sound from the sea surface,** *J. acoust. Soc. Amer.* **25,** 3, 566–570, May 1953.

The study of scattered sound from a sea surface can furnish information concerning the geometry and the kinematics of the sea surface. In order that such information may be obtainable from the experimental data, a theoretical analysis of the problem is needed. The result of this analysis is a scattering coefficient σ. For short-wave radiation, σ depends only on the rms values of the slope of the sea surface in two mutually perpendicular directions. For long wave radiation, σ depends on direction and wave length of the sinusoidal components of the surface waves. So experiments with short waves yield much less information about the sea surface than do those with long waves.

W. H. Muller, Holland

Ballistics, Detonics (Explosions)

(See also Revs. 15, 16, 190)

331. **Gohlke, W., On the internal ballistics of the powder rocket** (in German), *ZVDI* **95,** 17/18, 519–525, June 1953.

This is a review article intended to fill a gap in the German literature. It includes a description of solid propellant rockets, a derivation of the interior ballistic equations for tubular-grain solid propellant rockets, and a discussion of the influence on burning rate and pressure of powder properties and motor parameters. Particular attention is given to discussing the influence of the powder-gas flow. J. Lorell, USA

332. **Besse, L., Calculus of probabilities and ballistic applications** (in French), *Mém. artill. fr.* **27,** 2, 349–471, 1953.

This completes what amounts to a treatise on probability and statistics with applications to exterior ballistics—in 15 chapters and 11 appendixes. Previous chapters appeared in the title journal in 1952 and 1953. Here the author discusses the reliability of the mean, the determination of the characteristic elements of the dispersion, the distribution of ranges, and the proving-ground dispersions, with reference to observed data. The treatise is exhaustive but claims no mathematical originality. Its chief value is in its direct applicability to practical problems in the theory of accuracy of fire. A. A. Bennett, USA

Soil Mechanics, Seepage

(See also Rev. 42)

333. **Meyerhof, G. G., Some recent foundation research and its application to design,** *Struct. Engr.* **31,** 6, 151–167, June 1953.

Author discusses the bearing capacity of shallow and deep foundations under a central load, and the effects of eccentricity and inclination of the load are indicated. Total and differential settlements of foundations are estimated in terms of soil and foundation characteristics and stiffness of structure. The settlement stresses in foundation and superstructure are considered, and recent observations on brick walls and building frames are analyzed. Lateral movement and tilting of foundations are estimated and illustrated by results of tests on model portal frames on clay and sand.

The author is to be commended on this paper, which is an important contribution to structural engineering.

R. E. Gibson, England

334. **Adamson, B., and Brown, B. D., Water input profile determinations on injection wells in secondary recovery fields,** *J. Petr. Technol.* **5,** 6, Sec. 1 and 2, 13–17, June 1953.

Downhole flow rates of injection water are determined by the interface velocity method which, in this case, consists of establishing an interface between two liquids of different electrical resistivities. Authors employed fresh and salt waters. Water input rates determined in this manner and correlated with caliper logs provide satisfactory input profiles. Technique may also be used to locate casing seats. Injection profiles and correlation logs for seven wells are presented. Authors conclude that input profile data are important to the success of a secondary recovery program. S. R. Faris, USA

335. **Söhne, W., Pressure distributions in arable soil and its deformation** (in German), *Kolloid Z.* **131,** 2, 89–96, May 1953.

Paper gives the results of measurements made on arable soils

under the loading of wheels and rolls. Diagrams allow the reader to deduce the behavior of such soils of various granulometry, porosity, and moisture. The results of the measurements are interesting, not only for agricultural purposes, but also for general soil mechanics and foundation engineering.

R. G. A. Spronck, Belgium

336. de Josselin de Jong, G., and Geertsma, J., The stress distribution around vertically drilled holes in sandy terrain, internally supported by a heavy liquid (in Dutch), *Ingenieur* **65,** 9, M.1–M.5, Feb. 1953.

Determination of the stresses in the various regions. Introduction of new terms: *fallible* instead of *plastic*, for the zone of limiting equilibrium, and *compatible* instead of *elastic*, for the region distant from the hole.

To simplify the computation, an approximation is introduced, producing an error negligible for current conditions. Formulas are elaborated, describing the stresses in the various regions and the demarcation lines between them.

From authors' summary by R. G. A. Spronck, Belgium

337. Henye, J., Designing footings with the aid of nomographs (in Hungarian), *Mélyépítéstudományi Szemle* **2,** 6, 316–324, June 1952.

The permissible intensity of loading which determines the width of footings does not depend solely on the physical properties of the soil but on the bearing area of the soil, i.e., on the geometrical dimensions of the footing as well. The exact dimensions of the footing are given in the case of long footings and closed-surface footings by equations of the second and third degree, respectively. Comparative calculations show that various modern theories based on the ultimate bearing capacity of the soil give almost identical results. After the working loads and the physical characteristics of the soil have been established, footings can be rapidly and economically designed or the foundation plans controlled with the aid of the charts.

Courtesy of Hungarian Technical Abstracts J. Henye

Micromeritics

(See also Revs. 170, 171, 283)

338. Greshaev, A. D., On the gravitation theory of motion of suspended alluvial materials (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 937–946, June 1953.

Critical remarks on some fundamental concepts of the theory, which was founded by M. A. Velikanov ["Motion of alluvial materials," Moscow 1948; and title source, no. 11, 1951] as an apposite to the diffusion theory. Paper points out that in the flow of the solid and fluid phase through a horizontal plane, both cannot occupy the whole area simultaneously and so the "fundamental kinematical relationship" and the expressions for momentum changes in the new theory are not correct. A new term "lifting work" of the theory cannot re-establish the theorem of conservation of mechanical energy, because there are losses of it in turbulent flow of pure fluids and of fluids with suspended solid particles as well. When derivating the fundamental differential equations of the theory, the sum of products of changes of momentum components by velocities was incorrectly put equal to zero. The approximations which lead to the expression for the distribution of solid particles with depth are objectionable and the result does not agree with observed facts (the content of solid particles on the surface of even very turbid water is always zero). At last an old relation of the diffusion theory between the turbidness of water and its kinematic and dynamic quantities is established in an elementary way, which enables the use of this theory to flows of very turbid water.

A. Kuhelj, Yugoslavia

339. Kalinske, A. A., Settling rate of suspensions in solids contact units, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 186, 8 pp., Apr. 1953.

The design and performance of clarification basins are interpreted in terms of published data on settling velocity of suspension. The required settling area usually ranges from $^1/_{11}$ to $^1/_3$ of the ratio of the flow to the settling velocity, and the depth of the clear water over the sludge should be at least $^1/_7$ of the diameter for easy take-off.

C. F. Bonilla, USA

340. Jerlov, N. G., Influence of suspended and dissolved matter on the transparency of sea water, *Tellus* **5, 1,** 59–65, Feb. 1953.

The transparency at different levels in the sea as recorded by means of a transparency meter is compared with the distribution of suspended particles studied with the aid of a Tyndall meter. A simple procedure is used to distinguish between different components of light extinction and to derive values of the content of the dissolved yellow substance. The distribution of yellow substance is illustrated for the transition area between the Baltic and the Skagerrak and for the outflow of the Göta Älv. It is emphasized that the content of yellow substance may often be considered as a characteristic property of a water mass.

From author's summary by Ruth N. Weltmann, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 35, 36, 37, 38, 39, 80, 278, 296, 304, 329, 336, 340)

341. Kuessner, H. O., On the mathematical treatment of movements of the earth's crust, Inst. Fluid Dynamics and appl. Math., Univ. of Maryland, Lecture Ser. no. 22, 20 pp., Apr. 1953.

The earth's crust is represented by a homogeneous elastic plate "floating" on a highly viscous fluid of infinite thickness. On the assumption of relatively small movements, equations of motion can be linearized. The resulting general equations are applied to a few special problems which can be treated by use of certain operators. Resulting solutions based on certain load patterns of the plate are applied to geological "grabens," ring mountains on the moon, and folded mountains.

B. Gutenberg, USA

342. Housner, G. W., Martel, R. R., and Alford, J. L., Spectrum analysis of strong-motion earthquakes, *Bull. seism. Soc. Amer.* **43,** 2, 97–119, Apr. 1953.

Beginning with the well-known expression for displacement at any point in a structure as the sum of normal modes of vibration, authors proceed to show that displacement can be written as a summation of products of three quantities. Two of the three quantities have to do with physical properties of the structure, while the third is a function of ground acceleration, damping ratio, and frequency of the mode involved. If the third quantity is computed for particular values of the mode frequency and the damping ratio, a time history is obtained of a simple oscillator as it responds to the assumed ground acceleration. The maxima for a number of oscillators of different frequencies plotted as a function of period of oscillation with damping ratio as a parameter give a curve called the "earthquake spectrum." By using an analog computer, authors have obtained several such spectra for each of two

components of 14 strong-motion earthquakes. These spectra, 88 in number, show that a small amount of damping has a great effect upon the magnitude and shape of a spectrum. Most of the spectra investigated approximate rather closely a typical form. Location of the earthquake seems to have no significant effect upon the shape of the spectrum. E. A. Ripperger, USA

343. **Jardetzky, W. S., and Press, F., Crustal structure and surface-wave dispersion, Part III: Theoretical dispersion curves for suboceanic Rayleigh waves,** *Bull. seism. Soc. Amer.* **43,** 2, 137–144, Apr. 1953.

The characteristic equation for wave propagation through a media consisting of a liquid layer overlying two solid layers is derived. Calculations are given for the group velocity as a function of wave period for three different cases corresponding to an ocean overlying a granitic (5.5 km/sec) and basaltic (6.9 km/sec) basement which in turn overlies a medium of 8.1 km/sec. The third case corresponds to a single basement of 7.9 km/sec velocity. The second and third cases have the same group velocity curve in the period range from 15 to 40 sec; for $T > 40$ sec the two diverge. The first and third cases are most easily distinguished in the period range from 23 to 40 sec. The accuracy of measurement of Rayleigh waves from earthquakes which have traversed an all oceanic path is sufficient to detect this difference.

C. B. Officer, Jr., USA

344. **Griffin, W. R., Approximation to the lateral variation of residual gravity due to a frustum of a vertical cone,** *Geophysics* 18, 2, 401–415, Apr. 1953.

Difference in vertical component of gravity due to uniform frustum from that due to uniform coaxial cylinder is investigated. Approximation is derived giving results in terms of ratio of distance from axis to height Z_T above top of frustum, assuming radii of frustum to be small compared with Z_T. Special cases are examined, and results are presented in graphical and tabular forms and compared with field observations of salt domes.

K. E. Bullen, Australia

345. **Skeib, G., Applications of dimensional analysis in meteorology** (in German), *Z. Meteor.* **7,** 3, 73–77, Mar. 1953.

Applies well-established principles of dimensional analysis to the development of formulas of interest in meteorology. Included as illustrative examples of the method are: (1) Variation of pressure and density with height of a homogeneous atmosphere; (2) propagation of temperature waves in the earth's crust; (3) a psychrometric formula; (4) the Rayleigh light-scattering formula; and (5) Rayleigh's criterion for thermal convection. Greater flexibility would have resulted using the units of physical chemistry (M,V,T,R,Θ) rather than the (M,L,T,Θ) system used in the article. J. M. DallaValle, USA

346. **Kaplan, L. D., Regions of validity of various absorption-coefficient approximations,** *J. Meteor.* **10,** 2, 100–104, Apr. 1953.

Elsasser's integral for the absorption by a periodic line pattern is evaluated and used to examine the validity of various approximations concerning the absorption coefficient. It is found that composite absorption curves, obtained by ignoring overlapping for small optical paths and ignoring the pressure-dependent term in the denominator of the expression for the absorption coefficient for large optical paths, may be applicable to calculation of radiative heat transfer in the atmosphere.

It is shown that the theoretical prediction of the "square-root law" is supposed to be valid. An explanation is given for the apparent experimental verification of this law.

From author's summary

347. **Graham, R. D., A new method of computing vorticity and divergence,** *Bull. Amer. meteor. Soc.* **34,** 2, 68–74, Feb. 1953.

A method of computing the horizontal divergence and relative vorticity of a wind-velocity field is described. First, the wind direction and speed are mapped by an isogon-isovel analysis. The Bellamy system of determining vorticity and divergence from the values of the wind direction and speed at the vertexes of a polygon is then used. By plotting wind-velocity vectors on a rotatable transparent disk, the author shows how the desired quantities can be obtained simply and quickly. The method uses an equilateral triangle as a basis, although it can be adapted to other polygons. Although the application of the graphical computer described here is to the reduction of meteorological data, it offers a simple graphical method of vector differentiation which may be of value in other work. W. R. Hawthorne, England

348. **Sato, T., On the structure of cold vortex,** *Pap. Meteor. Geophys.* **3,** 2, 157–171, Aug. 1952.

The structure of certain atmospheric vortexes is examined dynamically. Assuming the motion to be symmetrical about a vertical axis, frictionless and autobarotropic, author derives equations of the form of discontinuity surfaces from the momentum, vorticity, and energy equations. It is shown that the discontinuity surface between cold core and surrounding tropospheric air stretches upward with increasing slope as the axis is approached, and that between the warm core and stratospheric surroundings it hangs down like a funnel. The inclination of the discontinuity surfaces is larger when the wind difference is large and when the temperature difference is small. H. L. Kuo, USA

349. **Tojo, S., The dynamics of a vortex embedded in a constant zonal current,** *Geophys. Mag., Tokyo,* **24,** 2, 123–129, Nov. 1952 = *J. Meteor.* **10,** 3, 175–178, June 1953.

The condition that the absolute vorticity be conserved is applied to the model of a symmetric vortex embedded in a constant zonal current. It is shown that the radial variation of the rotational component of the wind must then be according to the first-order Bessel function. The speed of propagation of the model vortex is found as a by-product of this result. Finally, it is shown that the maximum wind in such a model can be determined from the depth of the corresponding pressure-height field and the size of the vortex.

From author's summary by P. F. Byrd, USA

350. **Batchelor, G. K., The conditions for dynamical similarity of motions of a frictionless perfect-gas atmosphere,** *Quart. J. roy. meteor. Soc.* **79,** 340, 224–235, Apr. 1953.

The general significance of the Richardson number (dimensionless parameter) for motions of a frictionless perfect gas of variable density subject to gravity and various possible forms of the said parameter are examined in an elementary way. It is shown that, if the flow fields are such that the pressure and density everywhere depart by small fractional amounts only from the values for an *equivalent* atmosphere (properly defined) in adiabatic equilibrium and if the vertical length scale of the velocity distribution is small compared with the scale height of the atmosphere, then the Richardson number is the *sole* parameter governing dynamical similarity *for a whole flow field.* H. Arakawa, Japan

351. Scorer, R. S., Theory of airflow over mountains: II—The flow over a ridge, *Quart. J. roy. meteor. Soc.* **79,** 339, 70–83, Jan. 1953.

Although not nearly so important a research contribution as part I by the same author, this paper serves as an excellent review of a topic which has greatly proliferated in recent years.

Flow over mountains is subdivided into three categories, depending on the predominant forces governing the motion, called by the author "aerodynamic flow," "barostromatic flow," and "geostrophic flow." In aerodynamic flow there is no restoring force; in barostromatic flow vertical stability produces vertical disturbances; and in geostrophic flow the earth's rotation plays the critical role and motions are largely horizontal. Illustrative examples of each type of flow are given, along with a discussion of the problem of scaling-model experiments in each case.

The paper also adds some new results. Especially important is the clarification of the role of layers of neutral stability in the barostromatic case of air flow over ridges. It is shown that, if the neutral (adiabatic) layer is next to the ground, the wave length of the lee waves increases with growth in its depth until they vanish at some critical depth of this lower layer. This result explains very well the common observation of the lengthening and disappearance of the waves as daily convection sets in and their reappearance and shortening in the evening. It is also shown that, if the neutral layer is at middle levels, no steady laminar flow over the hill is possible. Joanne S. Malkus, USA

352. Murray, R., and Daniels, Sylvia M., Transverse flow at entrance and exit to jet streams, *Quart. J. roy. meteor. Soc.* **79,** 340, 236–241, Apr. 1953.

This paper presents experimental data in comparison with the theoretical prediction of the transverse mass divergence for isobar patterns typical of atmospheric jet streams. Specifically, cross-isobar flow is predicted for confluent-diffluent isobar patterns. Such a pattern is characteristic of the large-scale atmospheric jet stream in a velocity field which encompasses the maximum velocity along the jet axis. By statistical examination of wind observations near jet streams over the British Isles, the theory is found to be realistic. The magnitude of cross-flow components was obtained for the jet entrance, exit, center, and right and left of axis at 50-mb intervals approximating the jet wind field. Data indicate that the altitude of the entrance exceeds that of the exit.

P. Donely, USA

353. Long, R. R., Some aspects of the flow of stratified fluids, *Tellus* **5,** 1, 42–58, Feb. 1953.

A theoretical analysis of internal oscillations of a fluid with vertical gradients of density and velocity. This problem is of particular interest for meteorology; it can be applied also to density currents in river estuaries and in laboratory research with two or more different liquids. An "internal hydraulic jump" was produced in a flume carrying three different liquids. Two-dimensional equations of motion and continuity for any distribution of density and velocity along a vertical are integrated and give a complicated second-order differential equation. Several simple applications are discussed, as a flow with uniform velocity, flow over an isolated barrier, effect of shear on the motion of the stable fluid. In the second part of his study, author promises to present a report on an experimental investigation.

S. Kolupaila, USA

354. Clark, R. D. M., An investigation of certain short-period atmospheric micro-oscillations, *J. Meteor.* **10,** 3, 179–186, June 1953.

Oscillations studied were of periods less than one minute with amplitudes varying from one mm (1.33 mb) to more than 15 mm. Extensive measurements were made with a Macelwane electromagnetic microbarograph and galvanometric recorder.

Distribution of intensities with various atmospheric conditions (inversion, wind, temperature) are diagrammed; in particular, the greater intensities appear much less frequently with low-level inversions and with low wind speeds.

On the basis of these observations, author draws an analogy between turbulent flow in pipes and turbulent atmospheric flow under inversions, suggesting that the micro-oscillations are due to low-level atmospheric turbulence. A criterion for the development of turbulence in terms of velocity and temperature profiles is derived from the energy equation and the Fickian law. Reviewer believes this discussion to be confusing owing to author's identification of local change of total energy with energy transfer from current to eddies. M. Wurtele, USA

355. Berson, F. A., A quantitative analysis of the evolution of large-scale flow with regard to the effect of eddy motion, *Quart. J. roy. meteor. Soc.* **79,** 340, 210–223, Apr. 1953.

The theory of numerical forecasting [AMR **6,** Rev. 311] is extended to include the effect of an eddy motion represented by the departure of the daily value from a running five-day mean. Here the horizontal eddy transfer of vorticity, by the smaller eddies on approximately the cyclone-wave scale, is shown to be mainly directed *against* the gradient of vorticity in the mean flow. The transfer coefficient is, therefore, predominantly *negative* which may be very important but of dubious validity.

H. Arakawa, Japan

356. Cramer, H. E., A new approach to the problem of turbulent mixing, *J. Meteor.* **10,** 1, 46–53, Feb. 1953.

The principle of dynamic entrainment [AMR **5,** Rev. 295] is applied to construct two rather rudimentary models for the turbulent mixing process. Several numerical results obtained with the help of these models are discussed.

H. Merbt, Sweden

357. Palmén, E., On the vertical eddy flux of momentum in the trade-wind zone, *Proc. Indian Acad. Sci.* (*A*) **37,** 2, 189–194, Feb. 1953.

Assuming accelerations negligible, author computes from observations of hemispherical meridional wind velocity the stress exerted on the atmosphere by the earth's surface in the trade-wind region. Author finds surface stress to be 0.64 dynes cm^{-2}. Extension of the method shows that momentum is transported upward and downward from a height of 700 m. Author points out that the method used properly may be applied only in a relatively shallow layer near the earth because, as the meridional component decreases with height, accelerations become proportionately more important.

Reviewer believes that results are accurate and of considerable significance to studies of large-scale air motions. He points out that the method cannot be applied properly to observations averaged over short-time intervals or over distances appreciably less than the circumference of the earth.

R. G. Fleagle, USA

358. Chandrasekhar, S., The instability of a layer of fluid heated below and subject to Coriolis forces, *Proc. roy. Soc. Lond.* (*A*) **217,** 1130, 306–327, May 1953.

The manner of the onset of convection by thermal instability in a layer of fluid heated from below has been the subject of both experimental and theoretical investigations. There have been several attempts to apply the results of these investigations to a

number of meteorological and astrophysical problems. In connection with these latter meteorological applications, it was pointed out by Jeffreys [title source, 1928] that the rotation of the earth could have a pronounced inhibiting effect on the onset of instability in the earth's atmosphere, and that this effect should be considered before results were applied which were valid only in the absence of rotation. Despite the obvious strength of the arguments advanced by Jeffreys, the effect of rotation of the solid boundaries on thermal instabilities does not seem to have received a quantitative treatment. It is the object of this well-presented paper to provide such a treatment.

The principal results of the calculations in this paper are that there is an inhibiting effect of Coriolis force and that this effect is greater the larger the earth's angular velocity and the lower the kinematic viscosity. Remarks are made by the author on stellar atmospheres and on other problems to which the general principles of this paper apply. W. C. Johnson, Jr., USA

359. Weickmann, H. K., and aufm Kampe, H. J., Physical properties of cumulus clouds, *J. Meteor.* **10,** 3, 204–211, June 1953.

360. Warner, J., and Bowen, E. G., A new method of studying the fine structure of air movements in the free atmosphere, *Tellus* **5,** 1, 36–41, Feb. 1953.

Some results of a preliminary study, by radar observation, of the motion of clusters of freely falling metal foil (wartime designation "window") are given and the potentialities of the technique demonstrated.

Dropped by aircraft around a convective cloud, these foil clusters display the horizontal convergence of air into the cloud; when scattered as a continuous line above clouds, the vertical air velocities are made evident. The paper stiffening of the foil used in these experiments precluded its use in cloud, as the terminal velocity (100 cm/sec in dry air) was much increased.

Reviewer considers the method a valuable tool for the study of vertical motion and convergence, etc., whenever the velocity components to be studied are appreciable compared with the terminal velocity and rate of dispersal of the foil and should be especially suited to the study of entrainment into convective clouds. The rate of dispersal of suitable "window" may also have use in small-scale turbulence work at considerable heights.

E. L. Deacon, Australia

361. Riesbol, H. S., Snow hydrology for multiple-purpose reservoirs, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 189, 19 pp., May 1953.

Brief survey is given of factors to be considered in relations between snowfall and runoff. The way these relations are used to provide data for design of reservoirs is illustrated by a few typical examples. H. J. Schoemaker, Holland

362. Marshall, J. S., Precipitation trajectories and patterns, *J. Meteor.* **10,** 1, 25–29, Feb. 1953.

A characteristic "mares' tail" pattern of falling snow (observed in vertical section by radar) suggests that the snow is generated continuously, in compact generating elements; the pattern results from the snow's falling at constant velocity through the wind shear. For constant wind shear, the snow trails are parabolic and, before reaching the ground, become almost horizontal. The velocity of the pattern is that of the generating elements and can be compared with wind strengths aloft to locate the height of the generating elements when these elements are not detected by radar. From author's summary

363. Stability of rubble-mound breakwaters, *Wwys. Exp. Sta. tech. Memo.* 2–365, 77 pp., 4 tables, 39 plates, June 1953.

Paper reports experimental investigations of three principal aspects of the problem: (1) Accuracy of Froude scale-modeling of stability of rubble mounds under wave attack; (2) investigation of stability of a typical breakwater during progressive stages of construction of the core, armor, and cap rock sections for a considerable range of wave conditions; (3) investigation of the applicability of the Iribarren formula for the selection of cap rock.

Results include: (1) Demonstration of adequate modeling for scales of 1:30, 1:45, 1:60, and fair agreement of the models with one prototype case available for comparison; (2) development of a considerable body of generalized observations concerning the stability of breakwater components during all stages of construction; (3) determination of a large variation in the value of the Iribarren K factor with wave and breakwater construction parameters, and the relating of K with side slope, wave steepness, and relative wave length.

Reviewer believes this work provides the first comprehensive body of information on this subject and should promote economy and reliability of breakwater design. J. H. Carr, USA

Lubrication; Bearings; Wear

364. Kollman, K., and Hockel, H. L., Measurement of the thickness of the lubricating film in the main bearings of stationary Diesel engines (in German), *Motortech. Z.* **14,** 5, 133–137, May 1953.

The distance separating the surface of the crank-shaft journals and the white-metal lining of the main bearings of a six-cylinder engine was measured, using the variation in capacity between the pin and an electrode set in insulating material in the bearing lining. It is stated that variations in dielectric constant over the range 20 to 100 C did not introduce appreciable errors. Variation in capacity caused a variation in frequency of a primary circuit which was converted into a variation in voltage using a phase discriminator. The variation of voltage was thus a measure of the thickness of the lubricating oil film and was displayed on a cathode-ray oscilloscope. Variation was measured at several positions on two engines. On the second engine, a check on the accuracy of the method consisted of fitting electrodes to the upper and lower halves of the same bearing and displaced by 180°. The sum of the measured displacements at these two positions equaled the diametral clearance within close limits.

The effects of engine speed, engine load, and bearing temperature were studied over the range 200 to 360 rpm, 210 to 500 hp, and 45 to 65 C. The effect of increasing speed was to reduce the minimum film thickness and to increase the maximum film thickness in each case. In some cases, evidence of metallic contact between journal and bearing was noted over a small portion of each revolution. The effect of varying of horsepower output of an engine was slight. The effect of varying temperature was to reduce the minimum film thickness.

The authors state they regard the investigation as being of preliminary character, demonstrating the feasibility of measuring the fluctuations in lubricating-oil-film thickness during the revolution of an actual engine. F. T. Barwell, Scotland

365. Bouman, C. A., Properties of lubricating oil and engine deposits, London, St. Martin's Press, 1950, viii + 170 pp. $3.50.

Principles and problems underlying lubrication and fouling are treated. After a general introduction on lubrication, author discusses the classification of lubricating oils and their manufacture. Tests for fresh oils are given. Various forms of contamination likely to be present are dealt with and their effects in the engine

in service are discussed. Practical tests for lubricating oils are described.

Author has made extensive use of test results obtained while a member of the staff of the Delft Laboratory of the Royal Dutch/Shell Group. The present volume is a translation from the Dutch. Ed.

Marine Engineering Problems

366. Edstrand, H., Freimanis, E., and Lindgren, H., Experiments with tanker models. I, *Medd. SkeppsProvAnst. Göteborg* no. 23, 26 pp., 1953.

By using 1:22.5 scale models, fitted with turbulence stimulators, the resistance and propulsive qualities of V- and U-form forward sections of single-screw tankers are determined. With the models identical abaft of sector $13^1/_2$, four forward hull shapes varying from extreme U to extreme V were used. Resistance measurements covered a range of 10–17 knots, and the scale results were converted to full-scale size by Froude's method. Self-propulsion tests covered a range of 12–16 knots and were converted by the Continental method. It was found that at 16 knots the shaft power required for the extreme U is 12–13% less than for the extreme V. Since the tests were conducted in still water, other seaworthiness considerations such as slamming tendencies could not be determined. The author indicates that continued research will be performed with a modified U since the extreme U, in spite of its better power values, would not be adopted in practice because of the risk of slamming, etc., in a seaway.

M. S. Weinstein, USA

367. Leide, N. G., The brittle fracture problem from a shipbuilder's point of view, Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Paper no. 453, 18 pp., May 1953.

Author considers brittle fractures in ships in relation to temperature, loading, and material and gives some suggestions for avoiding them. Y. V. G. Acharya, Holland

368. Burrill, L. C., and Yang, C. S., The effect of radial-pitch variation on the performance of a marine propeller, *Shipbuilder* **60,** 539, 395–399, June 1953.

By a calculation procedure, the effect upon efficiency of seven radial variations of propeller pitch are investigated for the propellers working in the variable wake stream of twin-screw and single-screw vessels. It is concluded that: (1) From the viewpoint of over-all efficiency there appears to be no material advantage gained by radial variation of pitch. (2) There appears to be no special gain in efficiency accomplished by designs based upon minimum energy loss. (3) Since variations of pitch do not strongly influence efficiency, moderate pitch variations to reduce cavitation or flow breakdown may be desirable.

The paper under consideration is a condensation of an original article presented at the March, 1953, Meeting of the Institution of Naval Architects. F. E. Reed, USA

369. Smith, J., The use of heavy fuels in Diesel engines of marine auxiliary sizes, *N. E. Cst. Instn. Engrs. Shipb. Trans.* 69, part 7, 317–336, May/June 1953.

Please Note

The Subject and Author Indexes to APPLIED MECHANICS REVIEWS, Vol. 6, January-December, 1953, are to be published in separate pamphlet form and will be mailed together with the February, 1954, issue of APPLIED MECHANICS REVIEWS.

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